2.0 STUDY AREA INVESTIGATION

The Study Area investigation for the Portland Harbor Superfund Site (see Map 1.0-1) relies on data available from field investigations conducted by the LWG, with oversight by USEPA, as well as data from other sources. These investigations provide information on surface features, contaminant sources, meteorology, media-specific (e.g., groundwater, surface water, fish and shellfish tissue, and sediment) chemistry, geology, hydrology (surface water and groundwater), and ecology of the Study Area. This section discusses the field investigations conducted by the LWG and information/data collected from other sources (Section 2.1). The environmental data collected are described in Section 2.1, and the data quality assessment process for these studies is summarized in Section 2.2. Supporting details on the methods used to determine data usability are presented in Appendix A3. Finally, Section 2.3 describes removal actions that have already taken place within the Portland Harbor Superfund Site.

The Portland Harbor RI was designed as a multi-year program involving multiple rounds of data gathering and data evaluation as chemical distributions and the factors driving risks to ecological receptors and human health were identified. Site data were collected by the LWG during four major rounds of field investigations between 2001 and 2008, often timed around varying river stages, river flows, and storm events. The field investigations first began in 2001 in the Initial Study Area (ISA) as defined by the AOC, SOW, and Portland Harbor RI/FS Programmatic Work Plan (Programmatic Work Plan) as RM 3 to 9. As the studies proceeded, the Study Area was expanded from RM 1.9 to 11.8. Studies also included areas downriver of the Study Area to the confluence with the Columbia River at RM 0 and upriver to RM 28.4.

Each subsection of Section 2.1 describes the sample collection, and the maps presented in this section show the location of data collected from each sampling event by media (e.g., surface sediment, biota, surface water, etc.). Each sampling event was conducted under an USEPA-approved field sampling plan (FSP) and quality assurance project plan (QAPP) and health and safety plan (HSP). Analytical results were documented in a field sampling report (FSR), data report, and/or site characterization summary report (SCSR). Table 2.0-1 provides a list of the LWG FSPs, FSRs, and data reports submitted to USEPA for each major round of sampling.

In addition to the LWG field investigations, the LWG has also reviewed numerous documents that provided information regarding Portland Harbor and the lower Willamette River in order to develop the CSM and guide the sampling programs for this investigation. Physical, chemical and biological data from other parties were obtained primarily from individual LWG members, USEPA, Oregon DEQ, the USGS, and USACE. These investigations are summarized in Table 2.0-2. Section 2.1.5 and Appendix A1 provide additional information on the data collected by other parties.

2.1 REMEDIAL INVESTIGATION FIELD INVESTIGATION SUMMARIES

The Programmatic Work Plan (Integral, Windward, Kennedy/Jenks, Anchor, and GSI 2004) describes the activities to be undertaken by the LWG as it developed this RI for the Portland Harbor Superfund Site. The Programmatic Work Plan complies with the requirements of the AOC and SOW (USEPA 2001a) between the LWG and USEPA for conducting the RI/FS. This section of the RI discusses the preliminary and RI field investigations conducted by the LWG in accordance with the Programmatic Work Plan, AOC, and SOW. These field investigations include preliminary studies (Section 2.1.1), Round 1 RI field investigations (Section 2.1.2), Round 2 RI field investigations (Section 2.1.3), and Round 3 RI field investigations (Section 2.1.4).

2.1.1 Preliminary Studies (2001–2002)

Under a legal agreement with USEPA (2001a), the LWG conducted a number of studies as an initial phase of the Portland Harbor RI. These studies were necessary to scope the work plan for conducting the RI. This phase of studies included a multibeam bathymetric survey of the lower Willamette River (DEA 2002a), a juvenile salmonid residence time survey (Ellis Ecological Services 2002), and a Sediment Trend Analysis® (STA) survey (GeoSea Consulting 2001; SEA 2002a). On December 5, 2001, USEPA also approved performance of a sediment profile imaging (SPI) survey of the lower Willamette River (SEA 2002b). In spring 2002, an Acoustic Doppler Current Profiler (ADCP) survey was conducted to measure current velocities at several transects in the river (DEA 2002b).

2.1.1.1 Bathymetric Survey

A multibeam bathymetric survey conducted by David Evans and Associates, Inc. (DEA) took place in the lower Willamette River from the confluence with the Columbia River at RM 0 to 15.6 in accordance with the Multibeam Bathymetry Work Plan (DEA 2001). The bathymetric survey was conducted between December 13, 2001 and January 14, 2002, during a period of high water in the river. The methods used to collect and post-process the riverbed elevation data are provided in a field report (DEA 2002a). There were no deviations from the work plan. The results of the survey are shown in both hill-shade format and contours in the field report (DEA 2002a) and discussed further in Section 3 of this RI report. Water depths are referenced to the North American Vertical Datum of 1988 (NAVD88).

2.1.1.2 Juvenile Salmonid Residence Time Survey

A reconnaissance-level (pilot) survey was conducted in spring 2001 by Ellis Ecological Services, Inc. on the residence time of subyearling juvenile Chinook salmonids in Portland Harbor (Ellis Ecological Services 2002). This study was conducted in the lower Willamette River between RM 3.5 and 18.5. A comprehensive discussion of the methodologies and results is provided in the Technical Memorandum: Juvenile Salmonid Residence Time in Portland Harbor (Ellis Ecological Services 2002). This study was conducted to evaluate the feasibility of using miniature radio-tags (nanotags) for estimating residence time of the larger subyearling Chinook salmon (107–125 mm fork length) in Portland Harbor. Emphasis was placed on testing the methodology and approach rather than trying to develop definitive estimates of residence time for subyearling Chinook salmon. Specific objectives of the study were as follows:

- Test, evaluate, and refine proposed techniques for estimating residence time of subyearling Chinook salmon in Portland Harbor
- Develop a preliminary estimate of median residence time for radio-tagged subyearling Chinook salmon in Portland Harbor, particularly between RM 3.5 and 9.5, during the period of peak downriver migration
- Monitor ambient water quality (temperature, dissolved oxygen, conductivity, and turbidity) and flow conditions in conjunction with collection of fish movement and distribution data.

Only a small number of fish were measured during the capture efforts to minimize the effects associated with handling of fish. Therefore, no specific efforts targeted the quantification of fish size. However, fish captured during beach seine operations were noticeably smaller than those captured at the bypass facility. Fish captured in the beach seine ranged in size from approximately 55 mm (2.2 inch) to 110 mm (4.3 inch) fork length while fish captured at the bypass facility ranged in size from approximately 80 mm (3.1 inch) to 150 mm (5.9 inch) fork length.

A total of 43 Chinook salmon were successfully radio-tagged and released in the lower Willamette River upriver of Portland Harbor in May and June 2001. Of these 43 fish, 28 were located 266 times during the mobile tracking effort. None of the released fish was recorded on the Oregon Department of Fish and Wildlife (ODFW) fixed telemetry receivers. Fifteen fish were not located after release. Therefore the mobile tracking efforts were determined to be 65 percent effective in locating released fish. Sixteen subyearling fall Chinook were selected and used to obtain a preliminary determination of mean rate of downriver movement. These 16 fish were located 147 times during the mobile tracking effort. Ten of these 16 fish were from release two, 2 fish were from release three, and 4 fish were from release four. Six out of the 16 selected fish had adequate telemetry to allow calculation of a residence time estimate for the Study Area.

Map 2.1-1 shows the radio telemetry locations for the radio-tagged fish representing the median rate of downriver movement. Travel rate among the 16 fish was highly varied. Rates of travel ranged from 0.9 km per day (0.6 miles per day) to 15.3 km per day (9.5 miles per day). Residence time in the Study Area from RM 3.5 to 18.5 averaged 6.0 days (SD = 6.1 days, n = 16), ranging from 1.6 days to 26.9 days. The median residence time between RM 3.5 and 18.5 was 4.8 days.

No preference by fish for shallow water habitat was observed between the Multnomah Channel (RM 3.5) and the Broadway Bridge (RM 11.7). All of the 16 fish selected were observed in this reach of the river during mobile tracking operations and located a total of 54 times. Only 4 of these 54 observations were located in shallow water rearing habitat (Figure 2.1-1). In addition, there was no correlation identified between fish size and rate of downriver movement, and no diurnal effects were observed.

2.1.1.3 Sediment Trend Analysis® Survey

STA is a unique technique developed by GeoSea Consulting whereby patterns of net sediment transport in a waterbody are determined from relative changes in the grain-size distributions of bottom sediments in the waterbody. In addition, the technique enables the dynamic behavior of the bottom sediments to be assessed (i.e., net erosion, net accretion [erosion], dynamic equilibrium [stability], etc.).

The specific objectives of the STA (GeoSea Consulting 2001; SEA 2002a) for this site were the following:

- Collect approximately 850 sediment grab samples from the Willamette River from the mouth to the Willamette Falls (RM 26) downstream to the confluence with the Columbia (RM 0) and in the Columbia River approximately 1 mile upstream and downstream of the confluence of the Willamette with the Columbia River
- Analyze each of the sediment samples for its complete grain-size distribution and establish, using the STA technique, the present patterns of sediment transport
- Determine areas of sediment erosion, stability, and deposition as inferred by this technique.

Sediment grab samples were collected during the period September 15, 2000 through September 29, 2000 using a van Veen type grab sampler. This device samples the top 10 to 15 cm of sediment. In most instances, samples were obtained at predetermined locations; however, where shoreline structures (e.g., docks and marinas) and moored vessels interfered with navigation, samples were collected as close as practicable to the planned position. A total of 935 sample sites were visited, of which 99 samples were found to be “hard ground” (i.e., cobbles or bigger, or scoured bottom, or wood debris covering the bottom) and no sample could be taken. A site was designated as “hard ground” after three separate drops of the grab sampler failed to retrieve sediment.

The sediments of the Willamette River (summarized in Table 2.1-1) vary widely, from coarse sand in the upstream portions of the river near its confluence with Clackamas River, to mainly sandy mud near the mouth where it enters the Columbia River. To facilitate presentation and discussion of the results, the river was divided into seven reaches or segments, starting from Reach 1 near Willamette Falls. The most common sediment types were sand, muddy sand, and sandy mud, which account for 83.5 percent of all the samples (Table 2.1-1). Approximately 10 percent of the samples were “hard ground,” where no sample could be obtained after three attempts with the grab. Most of these samples were found in the upstream part of the river, but there were a few locations (e.g., in Multnomah Channel) where wood debris covered the bottom.

A total of 154 transport lines were selected to provide a pattern of sediment transport in the river. The transport lines were grouped into sixteen transport environments (TEs), starting from TE1 at the upstream end of the survey area (i.e., near Willamette Falls). A Transport Environment is defined as an area within which transport lines are associated both geographically and “behaviorally”. Generally, transport lines cannot be continued from one TE into another, because to do so decreases the statistical significance of the line (samples in the new TE are not related through transport to the samples in the line). Thus, a region in which transport lines naturally end (and begin) is a boundary between TEs. Map 2.1-2a–b shows the sediment types and sample locations in each of the seven reaches sampled in the survey.

2.1.1.4 Sediment Profile Image Survey

A SPI survey was conducted by SEA (2002b) in the lower Willamette River from RM 0 (the Willamette's confluence with the Columbia River) upstream to RM 15.7 (the upstream edge of Ross Island) from November 26, 2001 through December 11, 2001. Prior to the start of the survey, a complete sampling and analysis plan (SAP), QAPP, and HSP were submitted to USEPA (SEA 2001). This survey was completed in accordance with those plans.

The purpose of this study was to provide reconnaissance information on physical and biological features of surface sediments in the lower Willamette River from Ross Island to the Columbia River. These data, in addition to information from other preliminary sampling efforts (e.g., bathymetric survey, STA® survey), provided information needed to develop an effective approach to the RI/FS for sediments in the lower Willamette River.

Specifically, the objectives of the SPI survey were to generate and supplement area-wide information on the following:

- Grain-size distributions in sediments
- Patterns in physical disturbance of sediments
- Benthic community distributions in sediments
- Gradients in benthic habitat conditions, both in the main river channel and in nearshore areas.

SPI images were obtained from 478 stations in the lower Willamette River from RM 0 to 15.7. In general, stations were located along regularly spaced cross-river transects (Map 2.1-3).

Along each transect, the greatest number of stations were placed in the nearshore areas (those areas having water depths of 20 ft or less, Columbia River Datum [CRD]). It was anticipated that the nearshore areas would exhibit the greatest heterogeneity of sediment types, and potential land uses and habitats. Nearshore stations accounted for about two-thirds of the total number of stations sampled. The remaining stations were located within the federally maintained navigation channel or the main river stem.

Because of its more uniform depths and physiography, benthic conditions in the channel were considered likely to be less variable than nearshore, off-channel areas.

The Study Area was also divided into three upstream-downstream subareas with different sampling densities as described below. The most dense station grid was located between RM 3.5 and 9.2. SPI data from this area contributed to the development of RI sampling strategies and assisted in the interpretation of other data types. The river segments located downriver between RM 0 and 3 and upriver between RM 9.7 and 15.7 were sampled at a lower station density. These data catalog general bottom conditions and habitats in these river segments and helped locate reference areas for the RI in upstream areas.

A total of 523 images from 478 stations were analyzed. Replicate images were analyzed at 45 stations (9 percent replication). Physical parameters measured include prism penetration depth and sediment grain size. Biological parameters measured include apparent redox potential discontinuity, methane, and benthic infaunal succession stage. The complete results of the SPI survey are detailed in SEA (2000b).

2.1.1.5 Acoustic Doppler Current Profiler Survey

ADCP data were collected in the river by DEA during a high water event on April 19, 2002 (DEA 2002b). The ADCP was mounted on a 30-ft survey vessel, and transects were taken at RM 1, 2, 2.5, and 3.1 (Multnomah Channel), RM 4 and 4.6 (into Port of Portland Terminal 4 Slip 3), RM 5.8 (St. Johns Bridge), RM 6.3 (offshore GASCO), RM 6.8 (into Willamette Cove), RM 7.8 (offshore Willbridge Terminal), RM 8 (from Coast Guard Station, across Portland Shipyard to the west bank), Swan Island Lagoon (two short transects—one across mouth, one at the upper end), and RM 9.6, 10, and 11 (see Map 2.1-4). The river stage at the time of the data collection was approximately 11.6 ft CRD at the Morrison Street Bridge.

Water velocities obtained from the ADCP survey ranged from an upstream velocity of nearly 1 ft/second (upstream flow in back eddy) to a downstream velocity of 2 ft/second. Flows across the transects were computed at approximately 70,000 cubic feet per second (cfs) above Multnomah Channel and approximately 35,000 cfs below Multnomah Channel. The Willamette River flow on April 19, 2002 was roughly double the average Willamette discharge rate of about 32,000 cfs.

2.1.2 Round 1 RI Field Investigations (2002–2004)

Round 1 data collection for the Portland Harbor RI was conducted from June 2002 through February 2004 and results were presented in the Round 1 SCSR (Integral 2004a) and in the following study-specific FSRs:

- Aquatic plant and amphibian/reptile reconnaissance (Windward 2003a)
- Epibenthic invertebrate sampling using multiplates (Windward 2003b)
- Lamprey harvest reconnaissance survey (Kennedy/Jenks 2003)

- Nearshore deposition/erosion monitoring using sediment stakes (Anchor 2004a)
- Summer 2002 river-wide bathymetric survey (DEA 2003a).
- May 2003 multibeam bathymetric survey (SEA and DEA 2003; DEA 2003b)
- February 2004 multibeam bathymetric survey (DEA 2004a)
- Juvenile lamprey reconnaissance (SEA and Windward 2003)
- Benthic infaunal biomass reconnaissance survey (SEA and Windward. 2003)
- Soft-bottom benthos tissue reconnaissance (SEA and Windward 2003)
- Seep reconnaissance survey (GSI 2003a)
- May 2003 ADCP survey (DEA 2003c)
- January 2004 ADCP survey (DEA 2004b).

Except where noted in the FSRs or as modified by subsequent correspondence between the LWG and USEPA, all sample collection activities followed the procedures described in the Round 1A and Round 1 FSPs (SEA, Windward, Anchor, and Kennedy/Jenks 2002a, 2002b) and the Fish Tissue Sampling Standard Operating Procedure (SOP) (SEA, Windward, and Kennedy/Jenks 2002a). Fish tissue sample processing, including compositing, homogenization, and shipping, followed the procedures detailed in the Fish Tissue Compositing and Homogenization SOPs (SEA 2002c; SEA, Windward, and Kennedy/Jenks 2002b). All laboratory analyses follow the USEPA-approved Round 1 QAPP (SEA 2002d).

2.1.2.1 Summary of Round 1 Field Activities

The following tasks were carried out according to the Round 1A FSP, which was approved by USEPA on May 5, 2002 (SEA, Fishman, Ellis, Windward, Anchor, and Kennedy/Jenks 2003):

- Juvenile salmonid mark/recapture pilot study
- Collection of fish tissue for chemical analysis
- Epibenthic invertebrate sampling using multiplates
- Aquatic plant and amphibian/reptile reconnaissance survey
- Adult lamprey harvest reconnaissance survey
- Nearshore deposition/erosion monitoring using sediment stakes
- Summer 2002 multibeam acoustic bathymetric survey.

Round 1 field activities included the following tasks, which were approved by USEPA in a letter dated September 20, 2002 (SEA, Fishman, Ellis, Windward, Anchor, and Kennedy/Jenks 2003):

- Beach sediment chemistry

- Sediment chemistry at sculpin, crayfish, and benthic infauna stations (collocated sediments)
- Benthic infauna survey
- Clams for tissue analysis
- Juvenile salmonids and resident fish tissue analysis

In addition, the following activities were performed:

- Seep reconnaissance survey
- Juvenile lamprey and benthic infaunal biomass reconnaissance surveys
- Soft-bottom benthos reconnaissance survey
- May 2003 multibeam acoustic bathymetric survey
- February 2004 multibeam acoustic bathymetry survey
- May 2003 ADCP survey
- January 2004 ADCP survey.

Each of these activities is described in more detail in the following section. Water column chemistry and subsurface sediment radioisotope studies were not conducted in this phase of the project. Both of these studies were conducted later in Round 2 and are discussed further in Section 2.1.3.

2.1.2.1.1 Juvenile Salmonid Mark/Recapture Pilot Study

A pilot study to gather information on mark/recapture methods for juvenile salmonids was conducted July 8-9, 2002. The study of residence time of subyearling Chinook salmon was originally scheduled to begin in May 2002 and continue through the peak period of downstream migration (i.e., late May through June). However, between the submission of the Section 10 fishing permit and research startup, the proposed research was required to be reviewed and approved by USEPA. USEPA decided that instead of emphasizing residence time of subyearling Chinook in the 2002 season, emphasis should be placed on the collection of fish for tissue analysis. The scope of the residence time study was reduced to a pilot study to evaluate the efficacy of using fluorescent elastomer tags for marking subyearlings and developing an estimate of recovery efficiency. These changes in priorities were discussed with National Oceanic and Atmospheric Administration (NOAA) Fisheries Service in May 2002.

Due to the time required for the USEPA review and approval, startup of the pilot study was delayed until mid-July. By that time, water temperature in the Study Area had increased to levels that were stressful to juvenile salmonids. Juvenile Chinook salmonids were captured by beach seine on July 8 and 9, 2002. Field personnel found that the stress of handling at the ambient water temperatures was too high to allow meaningful results for a tag-recovery-efficiency estimate. Therefore, sampling for these purposes was discontinued, and no information was developed in 2002 on the residence time of subyearling Chinook. There were no agency representatives present as observers during the brief study.

2.1.2.1.2 Collection of Fish Tissue for Chemical Analysis

The fish tissue collection program was approved as part of Round 1A. Collection of fish and crayfish tissue from the Study Area followed guidelines outlined in the Fish Tissue Sampling SOP (SEA, Windward, and Kennedy/Jenks 2002a). Eleven fish species and one crayfish species were identified for tissue analyses to obtain data for the BERA and BHHRA. The target species for the BERA were:

- Northern pikeminnow (*Ptychocheilus oregonensis*)
- Smallmouth bass (*Micropterus dolomieui*)
- Sculpin (*Cottus* sp.)
- Subyearling Chinook salmon (*Oncorhynchus tshawytscha*)
- Peamouth (*Mylocheilus caurinus*)
- Largescale sucker (*Catostomus macrocheilus*)
- Lamprey ammocoetes
- Crayfish.

Of these species, only lamprey ammocoetes could not be found in sufficient numbers for tissue analyses.[1]

The target species for the BHHRA were:

- Carp (*Cyprinus carpio carpio*)
- Black crappie (*Pomoxis nigromaculatus*)
- Brown bullhead (*Ameiurus nebulosus*)
- Smallmouth bass (*Micropterus dolomieui*)
- Crayfish.

In addition, walleye and largescale sucker were collected as alternative species for brown bullhead and carp, respectively. These alternate species were not used for tissue analyses because adequate numbers of bullhead and carp were caught.

Before fish tissue sampling began, the LWG established a fish sample processing field laboratory and field equipment storage area, located in former laboratory space at the

[1] A concerted effort was made to locate lamprey ammocoetes in the ISA by the LWG and tribal biologists over 4 days in September and October 2002 without success. Methods tested and observations made during this effort are reported in SEA and Windward (2003).

decommissioned ATOFINA plant (RM 7W) in Portland. This field laboratory was outfitted with a water de-ionizing unit, venting hood, two sinks, and all laboratory safety equipment listed in the SOP. David Terpening (USEPA) visited and approved the use of the field laboratory space. In addition, he observed a "dry run" of the fish processing procedures and approved the methodology being used. USEPA project managers Wallace Reid, Chip Humphrey, and Tara Martich conducted a final visit to the laboratory, where the fish processing team from Fishman Environmental Services clarified any additional questions about fish processing procedures.

During the Round 1A collection of subyearling Chinook salmon from June 24 through June 27, 2002, beach seining and dip netting were the only fishing techniques used. The beach seining procedure was observed by David Terpening and Joseph Goulet from USEPA, Helen Hillman from NOAA, and Jeremy Buck from the United States Fish and Wildlife Service (USFWS). As noted above, the intended mark and recapture pilot program for subyearling Chinook salmon was halted after signs of heat stress were observed in fish held in buckets prior to marking.

During the Round 1 collection of all remaining species from July 22 through November 10, 2002, six fishing techniques were used. These included beach seining, boat electrofishing, backpack electrofishing, trot line, angling, and crayfish traps. At the beginning of the Round 1 field program, fishing techniques, sample handling, and fish processing were observed in the field by David Terpening of USEPA and Eric Blischke from Oregon DEQ. Subsequent visits were made by Joseph Goulet (USEPA) and Helen Hillman (NOAA), who, along with LWG consultant field managers and field crew, helped clarify issues such as station definitions and appropriate fishing methods.

The LWG field teams collected fish in the Study Area, both day and night, over 79 days (Maps 2.1-5 through 2.1-11). A total of 1,870 fish were collected, including 863 sculpin, 419 crayfish, 128 largescale sucker, 90 smallmouth bass, 78 carp, 92 subyearling Chinook salmon, 64 brown bullhead, 35 northern pikeminnow, 48 black crappie, 30 peamouth, 18 yellow bullhead, 3 lamprey ammocoetes, and 2 walleye. Forty-two individuals participated in the fish tissue collection effort. Striplin Environmental Associates (SEA) staff coordinated the effort, which was carried out by personnel from Ellis Ecological Services, Fishman Environmental Services, Windward Environmental, Kennedy/Jenks Consultants, and Anchor Environmental. All people directly involved with the fishing effort were authorized to collect fish under the scientific taking permit granted by ODFW to Ellis Ecological Services. With the exception of juvenile lamprey, the 2002 fish sampling program was successful in collecting all target species at all target locations in the Study Area to satisfy the Round 1 data needs of the BHHRA and BERA.

Fish samples were processed at the field laboratory by laboratory staff led by Fishman Environmental Services personnel. Fish specimen sample handling and processing procedures followed those detailed in USEPA-approved project SOPs and QAPP. Following final agreement with USEPA on fish sample compositing schemes, frozen samples were shipped to Axys Analytical Services Ltd. (Sidney, B.C., Canada) for tissue homogenization.

2.1.2.1.3 Epibenthic Invertebrate Sampling Using Multiplates

The objectives of the Portland Harbor multiplate invertebrate sampling were to characterize the epibenthic organisms settling on multiplates placed in the Study Area and measure chemical constituents in tissue samples from these invertebrate epibenthic organisms for use in the fish, bird, and mammalian exposure models. It was anticipated that the multiplate biomass would represent accumulation via the surface water pathway.

Multiplate samplers were placed at 10 locations within the Study Area (Map 2.1-5) between July 26 and 28, 2005 (Windward 2005b). Members of the regulatory agencies and trustees were present on July 26, 27, 28, and September 7, 2005, to oversee field operations. Observers were Jennifer Peterson and Mikeel O'Mealy from Oregon DEQ and Eric Blishke from USEPA.

The multiplate samplers were deployed at the 10 locations. At each location, 4 arrays of 6 multiplate samplers (total of 24 multiplate samplers per station) (Figure 2.1-2) were deployed based on field determination of the most suitable location for each array. At most stations, 21 multiplate samplers were processed for invertebrate tissue analyses and 3 multiplate samplers were processed for taxonomic evaluation. At MIT002, 10 multiplate samplers were processed for invertebrate tissue analyses and 2 multiplate samplers were processed for taxonomic evaluation. At MIT007, 16 multiplate samplers were processed for invertebrate tissue analyses and 1 multiplate sampler was processed for taxonomic evaluation. Factors included in the suitability evaluation included water depth (at least 5 m to ensure adequate water depth later in the summer), tie-up point for the rope connected to the array, avoiding high traffic areas and prop-wash areas, and avoiding the dredge operation near Gasco.

Forty-four taxa representing 6 phyla, 10 classes, 16 orders, and 24 families were collected in sediments from the 21 multiplate samplers processed from the 10 locations in the study area. Dipterans (true flies) and oligochaetes were the most diverse taxonomic groups represented, with 10 and 12 taxa, respectively. All dipterans present were members of the chironomid family (midges) while two orders and four families of oligochaetes were present. Other taxa found were bivalves, crustaceans, arachnids (mites and water mites), nematodes, polychaetes, and trichopterans (caddisflies). Chironomids, oligochaetes, and bivalves were the most common taxonomic groups found. Chironomids were found in all 21 multiplate samplers while oligochaetes and bivalves were present in 20 and 19 samples, respectively. Abundance varied greatly between samples, but oligochaetes, on average, were the most abundant. Taxonomic richness varied by more than a factor of 3.

2.1.2.1.4 Aquatic Plant and Amphibian/Reptile Reconnaissance Survey

An aquatic plant and amphibian/reptile reconnaissance level survey was conducted between June 26 and 28, 2002 to determine the presence or absence of these species throughout the Study Area. As specified in the Round 1A FSP (SEA 2002e), this reconnaissance survey was designed to determine whether aquatic plants and amphibians/reptiles should be included in the BERA. The study was designed to be a qualitative survey to determine presence/absence of amphibians/reptiles and plants in the Study Area. However, the presence of some amphibians may not have been recorded due to the survey being performed in late June after the hatching of egg masses. This study was not meant to be a quantitative estimation of amphibian/reptile or plant abundance or a quantitative survey of available amphibian/reptile or plant habitat.

Aquatic plant and amphibian/reptile surveys were conducted at 21 sampling sites located throughout the Study Area (Map 2.1-12). Sampling locations were selected based on river bank type and amphibian/reptile habitat quality. Most of the sampling locations were selected before going into the field to ensure that all representative bank types in the Study Area were sampled at least twice. The most common bank types occurring in the Study Area were riprap, unclassified fill, natural bank and river beach, and seawall. Many sampling sites coincided with the presence of in-water or shoreline structures that were considered to represent possible habitat. In addition, all designated habitat areas in the study area identified by the Willamette River Inventory (Adolfson et al. 2000) were included in the survey (e.g., Harborton Forest and Wetlands and Willamette Cove). Approximately one-third of the sample locations were selected while in the field based on visual observations of potential aquatic plant and amphibian/reptile habitat.

In general, the four bank types on which the majority of the sampling sites were located included riprap, unclassified fill, natural bank, and river beach due to the occurrence of available habitat in these areas. Other more developed bank types such as seawall and overwater structures were also visited, but did not support aquatic plant communities and, therefore, did not provide suitable amphibian or reptile habitat. Results of the plant and amphibian/reptile surveys are presented in Table 1 of the FSR (Windward 2003a). This table includes a physical description of each site and the plants, amphibians, and reptiles observed. The survey looked for evidence of salamanders but none was found. It was not possible to identify the species of the egg masses.

The aquatic plant survey identified 26 plant species, most of which were obligate and facultative wetland plant species, as defined by the National List of Plant Species That Occur in Wetlands (Reed 1996). The aquatic plant community was dominated by emergent hydrophytes that are able to live with their roots in water or muddy substrates. No submersed plants were found offshore in waters 2.4–3 m deep; however, a few submersed plants were identified close to the waterline near shore. These submersed plants included water moss, grasses, and sedge species.

The 21 sites sampled in this survey can be separated into three major types of aquatic plant habitat: 1) rocky or riprapped banks dominated by scrub-shrub wetland vegetation; 2) sandy beach where no emergent macrophytes were present in the water; and 3) sandy or rocky banks with emergent macrophytes present in the water.

Evidence of amphibian presence was observed at 6 of the 21 sampling locations. No reptiles were found at any sampling locations. In addition, frogs were heard calling in multiple habitat types, but not in response to the frog call recordings. Because no responses to the frog call recordings were heard, the nighttime frog call survey was terminated after the first night (June 26, 2002). However, surveying primarily during the day may have excluded evidence of the presence of adult amphibians. While this survey supports the presence of amphibian species in the Study Area in general habitat types, specific exposure areas were not defined in the Study Area.

David Terpening and Joseph Goulet from USEPA, Helen Hillman from NOAA, and Jeremy Buck from USFWS, observed the nighttime frog call procedures at one sampling location on the evening of June 26, 2002.

2.1.2.1.5 Adult Lamprey Harvest Reconnaissance Survey

Reconnaissance surveys of the lamprey harvest at Willamette Falls were conducted on June 26, 2002 and July 22, 2002 (Kennedy/Jenks 2003). The objective of the surveys was to observe the harvest and to identify the lamprey species harvested. LWG consultants observed lamprey harvests by the Confederated Tribes of Siletz on June 26, 2002, and by the Yakama Nation on July 22, 2002. Because these harvest dates were not fixed in advance and required attendance on very short notice, neither Oregon DEQ nor EPA technical staff were able to observe.

Three lamprey species are native to the Columbia River basin, the Pacific lamprey (*Lampetra tridentata*), the river lamprey (*L. ayresi*), and the western brook lamprey (*L. richardsoni*). The Pacific and river lamprey are both anadromous, and the adults of both species are parasitic. The western brook lamprey is a resident species and nonparasitic. Pacific lamprey is the species used by Tribes; adults are caught at Willamette Falls. River lamprey are extremely rare, although historically were known from the Willamette River. Western brook lamprey adults are considerably smaller than Pacific lamprey (4–6 inches long as adults vs. 1.5–2 ft long for Pacific lamprey).

All of the collected lampreys that were observed during the reconnaissance surveys were adult Pacific lamprey. The collected lampreys ranged in size from 400 to 650 mm (approximately 16–26 inches) indicating that they could not be the resident western brook lamprey. Only Pacific lampreys were collected during the harvest; tribal members were not familiar with the river lamprey. The western brook lamprey does not appear to be harvested for consumption by Native American tribal members.

2.1.2.1.6 Nearshore Deposition/Erosion Monitoring Using Sediment Stakes

A study using sets of index stakes placed in the intertidal regime at eight locations between RM 2 and 9 was conducted to evaluate potential changes in the beach elevation and to relate those changes to offshore/subtidal sediment elevation changes in the river channel determined by the bathymetric surveys (DEA 2002a). The nearshore data and possible relationship to erosion/deposition farther offshore are potentially useful in assessing various approaches, such as capping and attendant stability, for addressing sediment contamination problems. The duration of the study was from July 17, 2002 to December 20, 2002.

Sediment stakes were successfully deployed at eight of nine proposed locations in the Study Area (Map 2.1-13). At proposed location 2 (Schnitzer Steel), no suitable area for deployment and monitoring was available and stakes were not deployed. At each of eight sample locations, three 3-ft-long polyvinyl chloride (PVC) stakes were placed along a transect perpendicular to the shoreline. The 3-ft stakes were installed so that the top of each was approximately 1 ft above the sediment surface. The target mudline elevations for the locations of the stakes along each transect were the 10th percentile (low stakes), 50th percentile (median stakes), and 90th percentile (high stakes) of the river stage measured at the USGS gage station 14211720. The distribution of stakes at different elevations along a given transect allowed measurement of sediment changes under a variety of water level/river flow conditions.

Sediment levels relative to the tops of the stakes were recorded approximately once per month over the duration of the study from July 17 to December 20, 2002. The sediment levels were determined by measuring the distance from the top of each stake to the level of the surrounding unaffected sediment surface. Any debris, such as trash, sticks/branches, weeds, and leaves that accumulated around the stakes was removed prior to making sediment level measurements. Local scour around the stakes was insignificant in all cases.

The relationship between changes in beach mudline elevation and changes in mudline elevation farther offshore in the Study Area were investigated by comparing stake measurement data with data from bathymetric surveys in December 2001 and July 2002. Over the study interval, the river stage varied from 5.97 ft (gage datum) on July 22 to a low of 1.54 ft on October 13, after which a general increasing trend ensued, and the stage reached a high of 6.07 ft on December 17. Tidal excursions influence the river stage at Portland, so instantaneous surface elevations would consist of the fluctuating tidal elevation superposed on daily-average values. The tidal range varies throughout the year, but for the purposes of this study was assumed to be approximately 4 ft. Thus, the range of surface elevations over a given day would be approximately the daily-average value plus and minus a 2-ft tidal signal.

The lowest river discharge recorded was 8,080 cfs on August 18. No river discharge data are available after September 30, but the general trend apparent from 28 years of record is for increasing discharge volume after the summertime lows.

Sediment erosion and accretion in the Study Area are dynamic processes that respond to the shape of the shoreline, width of the river channel, and the stage and speed of the river. Because fluctuations in river stage and discharge are highly seasonal, it follows that sediment processes will also be seasonal. The sediment stake study spanned 5 months, and while it included the low-flow portion of the year and portions of the transitions before and after, it did not include the portion of the year when flows are typically highest. For example, the general trend among sediment measurements when river stage and discharge began increasing from the summertime lows was one of increasing erosion, which is what would be expected. Because the period when the highest stage and discharge conditions occurred was not captured, there is no information about how much more erosion may have occurred during that period. Thus, observations and resulting conclusions made during the study interval are not representative of typical annual conditions that can be expected to occur year after year. Similarly, sediment level changes determined from changes in bathymetry between December 2001 and July 2002 and changes indicated by the sediment stake measurements are not strictly comparable because they do not span the same interval.

2.1.2.1.7 Multibeam Bathymetric Surveys

DEA performed three bathymetric surveys from 2002 to 2004 to support sediment sampling during the RI, to define shoaling and scour areas relative to the previous survey conducted in December 2001/January 2002 as part of the preliminary studies, and to support future site investigations.

Summer 2002

The summer 2002 bathymetric survey was conducted in two phases. RM 2 to 11 was surveyed between July 3 and 18, 2002. Following a review of these data, RM 0 to 2.5 and RM 10.5 to 15.6 were surveyed between September 16 and 20, 2002. This bank-to-bank survey was conducted during the low-water season to obtain summertime riverbed elevations for comparison with the riverbed elevation data collected during December 2001 and January 2002. No regulatory agencies were present during the surveys.

DEA, under contract with SEA, conducted two additional bank-to-bank multibeam bathymetric surveys of the lower Willamette River during the summer of 2002. The primary goal of these surveys was to create a data set that depicts summertime riverbed elevations for 2002 that could be directly compared to the prior, January 2002, survey to determine areas of erosion and accretion within the study area. The survey was conducted from RM 0 (at the confluence with the Columbia River) to RM 15.6 (at the upper end of Ross Island), which was the same extent as the January 2002 survey (DEA 2002a). DEA also provided geographic information system (GIS) grids of the bathymetry and difference grids that depict the change in riverbed elevation from January 2002 to summer 2002.

The results from this survey were used to support sediment sampling during the RI, to define shoaling and scour areas relative to previous surveys, and to support future site investigations. Survey operations were conducted in two stages. The initial survey was conducted from July 3, 2002 to July 18, 2002, and data were collected from RM 2.0 to 11.0. After processing the data, significant changes were identified. The LWG determined that it would be beneficial to document the extent of changes for the remainder of the 15-mile study area. A second survey included the remainder of the 15-mile stretch of the Willamette with a 0.5-mile overlap at each end to identify any short-term change during the summer of 2002. From September 16, 2002 to September 20, 2002, data were collected between RM 0.0 and 2.5 (overlapping the July survey between RM 2.0 and 2.5) and from RM 10.5 to 15.0 (overlapping the July survey between RM 10.5 and 11.0).

In order to determine erosional and depositional areas of the river, the values of the grid nodes for the summer 2002 survey were subtracted from the grid node values for the January 2002 survey to produce the difference grids. A color scale was applied to the difference grids to aid in the analysis of the riverbed change. The color palette was designed to accentuate various levels of riverbed change that were defined by the scope of the project. All areas that changed ±0.25 ft, which is the approximate vertical error budget of the survey, were colored gray. Areas of accretion (or shoaling) were given red and orange hues while those areas that eroded were given blue hues. The color values correspond to the magnitude of the difference. For example, areas shaded with dark blues signify changes greater than light blues. An example of the results of this difference analysis is illustrated in Figure 2.1-3. This process is known as sun-illumination. Sun-illuminated images provide a more detailed presentation of the high-resolution multibeam bathymetric data than contouring and aid in the interpretation of river bedforms.

Differences were detected along steep slopes that may be the result of minor positioning differences between surveys. Slight differences may also be observed as long linear streaks in the difference images. Some of these minor differences, less than 0.50 ft, may be the result of lower quality outer beam measurements from the multibeam sonar. Extreme differences were defined in the color palette by purple (greater than 10 ft) and brown (greater than −30 ft). These extreme values are present at and around bridge piles throughout the survey area. Most of these areas do not represent change, but rather differences in depths collected along the vertical structure of the bridge piles or bulkheads at piers from the two surveys. Some of these areas represent actual change and are the result of dredging operations. An example of such an area is at the northeast end of Ross Island.

During the differing analysis, erroneous soundings were identified on sheets 6 and 7 in the original January 2002 data set. These soundings were removed from the January 2002 bathymetry grids, and new versions of these grids were issued as a revision with the difference grids on November 22, 2002. The revisions to the winter survey were used to produce the difference grids to keep erroneous soundings from creating invalid differences for the summer 2002 analysis as well as for future surveys. Results of the multibeam survey were presented as bathymetric contours and sun-illuminated imagery. Difference analysis was presented as a color-coded image.

The survey data were processed using a grid size of 1 m by 1 m to generate a digital terrain model. The results of the summer 2002 survey are shown in both contour and hill shade formats in the field report (DEA 2003a). Water depths are referenced to NAVD88. In addition, bathymetric survey difference maps, which show areas of riverbed shallowing and deepening, were generated in the report (DEA 2003a).

May 2003

DEA conducted a bank-to-bank multibeam bathymetric survey of the lower Willamette River from May 6 through May 28, 2003. The primary goal of this survey was to create a data set that depicts riverbed elevations for 2003 during high river flow that can be directly compared to prior surveys to determine areas of erosion and accretion within the Study Area. The survey was conducted from RM 0 (at the confluence with the Columbia River) to RM 15.6 (at the upper end of Ross Island), which was the same extent as previous surveys, summer 2002 and January 2002. The control used for the survey, data acquisition methodology, and data processing procedures are discussed in the field report (DEA 2003b).

DEA also provided GIS grids of the bathymetry and difference grids that depict the change in riverbed elevation from January 2002 to May 2003 and from summer 2002 to May 2003. The results from this survey were used to support sediment sampling during the RI, to define shoaling and scour areas relative to previous surveys, and to support future site investigations. The results of the May 2003 survey are shown in both contour and hillshade formats in the field report (DEA 2003b). Water depths are referenced to NAVD88. In addition, bathymetric survey difference maps, which show areas of riverbed shallowing and deepening were generated in the field report (DEA 2003b).

February 2004

DEA also conducted a bank-to-bank multibeam bathymetric survey of the lower Willamette River during February and March of 2004. The survey was a continuation of an ongoing sediment transport study in support of the RI. The primary goal of the February-March survey was to create a data set containing riverbed elevations for 2004 following a high river flow event (over 120,000 cfs) that can be directly compared to prior surveys to determine areas of sediment erosion and accretion within the Study Area. The survey was conducted from RM 0 to 15.6, which is the same extent as previous surveys in May 2003, summer 2002, and January 2002.

The results from this survey were used to support sediment sampling during the RI; to define shoaling and scour areas relative to previous surveys; and to support future site investigations. Survey operations were conducted from February 6, 2004 to March 6, 2004, with an additional day of acquisition required on March 26. The control used for the survey, data acquisition methodology, and data processing procedures are discussed in the field sampling report (Integral and DEA 2004; DEA 2004a). Included with the FSR was a set of full size drawings and project DVD-ROMs containing digital data, Arc/Info GRID files, AutoCAD drawing files, and plot files of final maps.

The results of the February 2004 survey are shown in both contour and hillshade formats in the field sampling report (Integral and DEA 2004; DEA 2004a). Water depths are referenced to NAVD88. In addition, bathymetric survey difference maps, which show areas of riverbed shallowing and deepening, were generated in the field sampling report (Integral and DEA 2004; DEA 2004a).

2.1.2.1.8 Seep Reconnaissance Survey

A seep reconnaissance survey was conducted between RM 2 and 10.5 on October 7 and 8, 2002. Representatives from SEA, Groundwater Solutions Inc. (GSI), and Kennedy/Jenks Consultants conducted the seep reconnaissance. Eric Blischke from Oregon DEQ and Renee Fuentes from USEPA accompanied representatives of the LWG on a subsequent tour of the identified seep areas on October 24, 2002.

For the purposes of the survey, a seep was defined as a location where water discharges from the ground either above or below the river surface. The definition of seep does not imply that the water from the seep is contaminated in any way absent some other obvious indicator of contamination (e.g., sheen or chemical odor). Seeps were identified during the survey based on at least one of the following criteria:

- Locations where seepage of water was directly observed
- Known past and current locations of petroleum, creosote, and other types of nonaqueous-phase liquid (NAPL)-containing seeps
- Locations where water was observed discharging from the backfill surrounding an outfall
- Locations where extensive iron (ferric hydroxide) staining of the bank materials was observed; these locations were considered potential seasonal seep locations.

Locations where healthy and/or phreatophyte vegetation also were noted as potentially indicating the presence of groundwater near the surface.

The scope of the approved seep reconnaissance work included:

- Perform a boat reconnaissance survey to identify bank seeps within the study area.
- Photograph, describe, and record the location of each seep with a global positioning system (GPS) instrument.

The objective of the seep survey was to inventory readily identifiable groundwater seeps present between RM 2 and 10.5 to support development of the BHHRA and groundwater CSM. The intended uses of the seep survey include the following:

- Identify groundwater seeps in areas where potential human contact could occur in order to identify beaches as a potential human use area to evaluate potential human health risks associated with exposure to groundwater

- Provide information to describe shallow groundwater interactions with the river for development of a groundwater conceptual model within the Study Area.

The seep locations and navigation waypoints illustrating the route of the survey are shown on Map 2.1-14. The locations of beaches that were identified as potential human use areas at or near where seeps were identified are shown on Map 2.1-14, which does not include other beaches identified as potential human use areas where seeps were not observed.

The reconnaissance survey was conducted during a low-stage period on the Willamette River after a drier than normal summer and fall. Each seep identified during the survey was visually examined for indications of contamination including discoloration, sheen, or obvious odor. Many seeps observed during the survey were characterized by the presence of reddish-orange staining from iron mineral precipitates interpreted to be ferric hydroxide. Iron bacteria slime growth also was commonly observed associated with seeps. The presence of iron-related staining and bacterial growth in the vicinity of seeps is considered diagnostic of the presence of groundwater except in a few situations where the obvious source of the staining is corrosion of steel pipes.

The locations where water was observed discharging directly from outfall pipes were not classified as seeps because of the uncertainty as to whether or not the source of the water was directly from groundwater or was surface drainage from upland areas. Descriptions of general types of seeps observed during the reconnaissance survey are provided in the following section. The seep reconnaissance survey report (GSI 2003a) provides the locations and descriptions of specific seeps catalogued during the reconnaissance survey; brief descriptions of the riverbank along the reconnaissance survey route between seep locations, and the seep category, as defined in the following section, for the catalogued locations. Digital photographs of the seep locations were taken and are available in the seep reconnaissance survey report (GSI 2003a).The types of seeps and potential seeps observed during the survey were categorized according to one or more of the following five types:

- Seepage line at the base of embankments
- Linear and point seeps at the foot of beaches
- Seeps from backfill surrounding outfalls
- Seepage of NAPL
- Potential seasonal seep locations.

These seep types are intended to be generalized descriptors of the types and occurrences of seeps observed and are not an exact and definitive classification as several of the seeps observed during the survey could be considered to have characteristics of more than one of these categories.

The seeps catalogued during this survey are limited to those that could be directly observed or were previously known at the time of the survey. There are likely areas of seepage that were not observed during the survey because of the presence of piers, bulkheads, riprap, dense vegetation, and other access constraints. Also, while the observed seeps are visible expressions of groundwater flow, the discharge represented by the seeps is likely to comprise only a small percentage of the total groundwater discharge to the Portland Harbor, with most of the groundwater discharging to the river probably occurring as submerged seepage.

2.1.2.1.9 Juvenile Lamprey and Benthic Infaunal Biomass Reconnaissance Surveys

On September 16 and 17, 2002, a field team consisting of SEA, Windward Environmental, Ellis Ecological, and Fishman Environmental personnel visited 21 of the 22 collocated sediment and tissue sampling stations, originally identified in the June 2002 LWG FSP (SEA, Windward, Anchor, Kennedy/Jenks 2002b) and as modified during the subsequent fishing efforts. On October 8 and 9, 2002, a field team consisting of two lamprey biologists from the Umatilla tribe (Aaron Jackson and Brandon Trelor), Helen Hillman of NOAA, and LWG consultants visited 11 lower Willamette sites for a follow-up reconnaissance using specialized lamprey electroshocking equipment (SEA and Windward 2003).

The main objective of this reconnaissance survey was to determine whether juvenile lamprey (ammocoetes) could be collected using backpack electroshockers or surface grab samplers in adequate numbers to allow for tissue chemical analyses. Also, because lamprey collection techniques included sediment grab sampling, an ancillary objective was to assess the apparent biomass and composition of the soft-bottom, benthic infaunal community to determine whether adequate biomass of infauna were present to allow for tissue chemical analysis.

Sampling was conducted on foot (backpack electrofishing) and from a boat. As warranted based on each station’s physical setting, shoreline habitats, and accessibility, beach electroshocking for lamprey ammocoetes and beach and subtidal sediment sampling (hand-held spoons, Ekman and van Veen grab samplers) for lamprey ammocoetes, soft-bottom benthos, and bivalves were conducted. Sediments were sieved through both 1.0 mm and 0.5 mm screens at a subset of stations, and representative benthic infauna specimens were retained for later examination in the laboratory, although no attempt was made to quantitatively sample the benthos. Infaunal organisms were identified to major taxonomic categories following the survey and bivalves were identified to the genus level.

The juvenile lamprey reconnaissance field report (SEA and Windward 2003) provides descriptions and locations of the stations visited during the September 2002 reconnaissance in chronological order, details on the lamprey ammocoetes electrofishing efforts and results at each station, and the major site-specific observations. The field report also provides a summary of the benthic infauna data, and conclusions on whether adequate benthic biomass might be collected at a given location to allow for chemical analyses of composite invertebrate tissue samples.

Lamprey

The backpack electroshocking was only successful at collecting lamprey ammocoetes at one (04R004) of the 16 stations sampled. Two lamprey ammocoetes were collected at this site and one specimen was released and subsequently re-found with the electroshocker. This suggests that the electroshocking approach is successful at finding lamprey ammocoetes when they are present. Electroshocking was not attempted at several stations without apparent suitable habitat, i.e., steep-sloped riprapped shorelines.

Other methods evaluated for catching lamprey ammocoetes included grab sampling and hand-scooping of beach sediments in areas that appeared to be suitable habitat. Beach and/or subtidal sediments were collected and sieved at 15 of the target stations. No lamprey ammocoetes were collected in the sediment grab samples. A small epibenthic dredge was mobilized for this reconnaissance but nearshore sediment dredging was not attempted at any station because of the shallow water levels, uneven bottom terrain, and nearshore structures (e.g., dolphins, piers, etc.). Given the apparent low abundance of lamprey ammocoetes in the area surveyed in mid-September, the probability of collecting lamprey ammocoetes in a sediment grab sample seemed quite low.

Overall, because numerous, apparently high quality habitat locations were sampled with both standard electro-backpacking and sediment sampling equipment without finding lamprey, it is doubtful that other methods would yield sufficient quantities of lamprey at this time of the year to allow tissues analyses.

Benthos

Sediments were collected and sieved at 15 of the target collocated stations. Soft-bottom benthos observed consisted of oligochaetes, bivalves, chironomids, and amphipods. Oligochaetes and chironomids were present in low abundances in most fine-grained (silts) areas. Amphipods were observed only at downriver locations (RM 2–3). The bivalve, *Corbicula* sp., was widespread in areas with an obvious sand fraction. With the exception of these bivalves at certain locations (where there were individual clams equal to or greater than about 3 cm in length), the tissue biomass of the soft-bottom infaunal assemblage appeared to be extremely low as a result of both relatively low abundances and the small size of individuals (e.g., most specimens passed through the 1.0-mm screen but were retained on the 0.5-mm screen).

Based on this reconnaissance effort, the only soft-bottom benthic organism that could potentially provide sufficient biomass for laboratory tissue analyses is the exotic bivalve, *Corbicula* sp. At several locations (02R001, 03R001, 05R001, 06R002, 07R003), *Corbicula* sp. were abundant and large enough to provide sufficient biomass for tissue chemical analyses with a reasonable effort (e.g., 1–2 days per site). In addition, large specimens of the mussel, *Margaritifera* sp., were collected at Station 05R002, but their origin at this location is uncertain because it is just off a public boat ramp and these specimens may have been transported and disposed there from elsewhere on the river.

2.1.2.1.10 Composite Beach Sediment and Collocated Surface Sediment Sampling

Composite surface beach sediment samples were collected at 20 beaches in the Study Area (Map 2.1-15) from October 9 through 14, 2002. At each beach, samples were generated by combining randomly selected, individual 0- to 15-cm beach sediment samples into a single composite. All beach sediments were collected using stainless steel hand corers. Mike Poulsen (Oregon DEQ) participated in the beach sediment collection and modified the definition (start or end point) of some target beaches during the field sampling event.

In-river surface sediments (0–15 cm) for chemical analyses to support the BERA were collected at two types of stations. First, as described in the FSP, collocated sediments were collected at 27 nearshore sculpin and crayfish tissue sampling stations (12 of these stations also included benthic infauna sampling stations). Second, surface sediments for chemical analysis were also collected at 10 additional benthic infauna stations to provide additional information on the distribution of benthic infauna in the Study Area. These stations were situated in both nearshore areas and in the navigation channel to supplement the distribution of the 27 sculpin/crayfish collocated stations. The collocated surface sediment samples were collected from October 16 through 25, with an additional sampling day on November 12, 2002. All surface sediments were collected using either a 0.1-m^2 van Veen grab sampler provided by SEA or a 0.3-m^2 hydraulic power grab sampler provided by Marine Sampling Systems. Collocated surface sediment sample collection procedures were observed by Dana Davoli (USEPA), Helen Hillman (NOAA), and Jennifer Peterson (Oregon DEQ).

2.1.2.1.11 Benthic Infauna and Clam Sampling

Soft-bottom benthic samples were collected from 22 stations in the Study Area (Map 2.1-16) from October 22 through 25, 2002. Benthic infauna samples were collected at 12 of the sculpin/crayfish collocated sediment stations and at 10 additional stations in both nearshore areas and in the navigation channel. Infauna were collected with a 0.1-m^2 van Veen grab sampler and sieved through a 0.5-mm sieve box. For the BERA, a single replicate was collected at each location to provide a qualitative indication of the benthic infaunal assemblages throughout the harbor.

During the juvenile lamprey/benthic infauna reconnaissance survey conducted in September 2002 (see Section 2.1.2.1.9), it was determined that the non-native bivalve species *Corbicula fluminea* was the largest and most widespread benthic invertebrate in the Study Area. In some locations, *Corbicula* appeared to be abundant enough to allow for the collection of sufficient biomass for tissue chemical analyses. Between October 29 and November 5, with an additional day on November 12, 2002, clam collection was attempted by repeated casts of a 0.1 m^2 van Veen grab sampler at five target locations. Also, at one location, an unsuccessful attempt was made to rake clams from a shallow subtidal beach. Clam collection was attempted over multiple sampling days at each location. After considerable total effort (over 500 casts with the van Veen grab sampler), two locations near the center of the Study Area yielded more than 150 grams of tissue, which is the minimum biomass required to conduct tissue analyses for a full suite of target analytes. Fifty-three grams were collected at a third station, while the remaining two stations yielded only nominal amounts of tissue.

2.1.2.1.12 Acoustic Doppler Current Profiler Surveys

DEA conducted two ADCP surveys of the lower Willamette River in May 2003 and January of 2004 in support of the sediment transport assessment for the RI (DEA 2003c, 2004b). Survey methods and results are discussed in these reports.

On May 13, 2003, DEA conducted an ADCP survey along four transects in the vicinity of Multnomah Channel at RM 3 (Map 2.1-4) during relatively low river levels. Six observations were conducted over a 14-hour period from high tide to high tide, through one low tide event. The transect profiles are presented in the 2003 ADCP survey report (DEA 2003c).

On January 31, 2004, DEA conducted an ADCP survey over a 9-hour period during a relatively high-flow event along 17 transects in the lower Willamette River between RM 0 and 11 (Map 2.1-4). The primary goal of the January 2004 ADCP survey was to measure current velocities within the Study Area during a high river flow event (over 100,000 cfs). The transect profiles are presented in the 2004 ADCP survey report (DEA 2004b).

2.1.3 Round 2 RI Field Investigations (2004–2006)

The Round 2 field investigations were performed from fall 2004 through spring 2006. Round 2A includes those investigations conducted in 2004, and Round 2B includes investigations conducted in 2005 and in the spring of 2006. Round 2 field investigations are discussed in the following FSRs or data reports:

- Shorebird foraging area and beach sediment chemistry (Integral 2005a)
- Surface sediment chemistry (Integral 2005a, 2006a)
- Subsurface sediment chemistry (Integral and Anchor 2005; Integral 2005b, 2006b,c, 2008a)
- Surface water chemistry (Integral 2005c,d,e, 2006d)
- Benthic sediment toxicity (bioassays) (Windward 2005a)
- Physical system information (Integral 2006e,)
- Natural attenuation (radioisotope cores) (Anchor 2005a,b)
- Groundwater pilot study—mapping tools and sampling methods (Integral 2005f)
- Groundwater pathway assessment (GWPA; Integral 2006f,g)

- Subyearling Chinook tissue (Integral and Windward 2005a, 2006a)
- Multiplate epibenthic invertebrate tissue (Windward 2005b; Integral 2006h)
- Benthic invertebrates and clam tissue (Windward and Integral 2005a, 2006; Integral and Windward 2006b)
- Mussel and lamprey ammocoetes tissue (Windward and Integral 2006, 2007)
- Cultural resources analysis (AINW 2005).

Except where noted in the FSRs, the data reports, or as modified by subsequent correspondence between the LWG and USEPA, all sample collection activities followed the procedures described in the following Round 2 FSPs and SAPs:

- Shorebird foraging area and beach sediment chemistry (Integral, Kennedy/Jenks, and Windward 2004)
- Surface sediment chemistry, subsurface sediment chemistry, and benthic sediment toxicity (Integral, Anchor, and Windward 2004; Integral 2005g; Anchor and Texas A&M University 2004)
- Surface water chemistry (Integral 2004b)
- Physical system information (Integral and West 2006; Anchor and Texas A&M University 2004)
- Groundwater pilot study—mapping tools and sampling methods (Integral 2004c)
- GWPA (Integral, Kennedy/Jenks, and Windward 2005; Integral 2005f,h,i,j,k,l, 2006i)
- Subyearling Chinook tissue (Integral, Windward, and Ellis 2005)
- Benthic invertebrate tissue (Windward and Integral 2005b,c).

All field sampling was conducted in accordance with the following HSPs:

- Round 2 HSP (Integral 2004d)
- Round 2 GWPA HSP (Integral 2005m).

All laboratory analyses follow the following USEPA-approved Round 2 QAPP:

- Round 2 QAPP (Integral and Windward 2004)
- Round 2 QAPP Addendum 1: Surface Water (Integral 2004e)
- Round 2 QAPP Addendum 2: PCB Congener Analysis in Sediment (Integral 2004f)
- Round 2 QAPP Addendum 3: GWPA Pilot Study (Kennedy/Jenks and Integral 2004)

- Round 2 GWPA QAPP Supplement to Addendum 3 (Integral 2005n)
- Round 2 QAPP Addendum 4: Subyearling Chinook Tissue Collection (Integral 2005o)
- Round 2 QAPP Supplement to Addendum 4: Subyearling Chinook Tissue Collection – Semivolatile Organic Compounds (Integral 2005p)
- Round 2 QAPP Addendum 5: Benthic Invertebrate Multiplate Tissue Collection (Integral 2005q)
- Round 2 QAPP Supplement to Addendum 5: Invertebrate Tissue Collection Using Multiplate Samplers (Integral 2005r)
- Round 2 QAPP Addendum 6: Sampling of Benthic Invertebrate Tissue (Integral and Windward 2005b).

2.1.3.1 Summary of Round 2 Field Activities

The purpose of Round 2A sampling was to collect sediment data for the RI and risk assessments and initiate data collection for the FS. The specific objective of the Round 2 sediment sampling program was to collect the following types of data:

- Beach sediment chemistry to support the BHHRA
- Shoreline and riverbed surface sediment chemistry to characterize chemical distributions in surface sediments and potential source effects to the river, and to support the human health and ecological risk assessments
- Subsurface sediment chemistry and physical data to characterize chemical distributions in subsurface sediments and potential source effects to the river, to support the FS and groundwater impacts assessment tasks, and to confirm the physical CSM
- Preliminary sedimentation samples (e.g., radioisotope cores of subsurface sediments) in areas that may have depositional processes to support development of the FS.

The purpose of Round 2B sampling was to fill in data gaps from previous studies to support then the remedial investigation, baseline risk assessments, and the FS.

2.1.3.1.1 Shorebird Area and Beach Sediment Sampling

Surface sediment sampling activities were conducted in shorebird foraging areas and human use beach areas accordance with the Round 2 FSP (Integral, Kennedy/Jenks, Windward 2004), the Round 2 QAPP (Integral and Windward 2004), and the Round 2 HSPs (Integral 2004f). Composite shoreline sediment samples were collected from July 26 through 30, and on November 5, 2004 at 21 shorebird foraging areas from RM 2 to 10, and 4 collocated shorebird foraging areas and potential human use beaches between RM 2 and 3. As described below, all of the Round 2A shoreline samples were collected close to waterline; these samples are generally referred to as “beach” samples in this report. The 25 Round 2A shoreline samples are indicated by a “B” (e.g., B001) in the station identification code on Map 2.1-15. The four collocated shorebird and human beach area locations stations are B001, B002, B003, and B005. For presentation purposes, Map 2.1-15 depicts the shoreline samples as a point only. The Surface and Beach FSR (Integral 2005a) provides a detailed description of the collection effort and a map that more accurately displays the actual shoreline area sampled.

At each beach sampling location, sediments were collected to a depth of 15 cm using a stainless-steel, hand-held coring device. A total of 28 composite beach sediment samples (including two field replicate samples and one homogenate split sample) were collected and submitted to the analytical laboratories for chemical testing. Similar to the beach composite samples, the replicate beach samples were composed of subsamples and were collected contemporaneously alongside each primary beach subsample. The replicate subsamples were composited and processed separately from the primary sample.

2.1.3.1.2 Surface Sediment Sampling

Surface sediment sampling activities were conducted in accordance with the Round 2 FSP (Integral, Anchor, Windward 2004), the Round 2 QAPP (Integral and Windward 2004), and the Round 2 HSP (Integral 2004d). Surface riverbed sediment grab samples (0–30 cm) were collected in the lower Willamette River from July 19 through November 5, 2004, at a total of 523 target locations distributed from about RM 2 to 25. All but 8 of these stations (i.e., 515 stations) were locations identified in the sediment FSP (Integral, Anchor, and Windward 2004) and were located in Portland Harbor from about RM 2 to 11 (Map 2.1-15). These Round 2A surface sediment stations are indicated by a “G” in the station identification code (e.g., G001). Six upstream stations (between RM 16 and 25) and two downstream (between RM 2 and 3) stations were added for chemical and toxicity sampling in October 2004 based on discussions between USEPA and the LWG. These stations are indicated by a “U” (upstream stations) or a “D” (additional downstream stations) on Map 2.1-15.

Five stations (G124, G126, G161, G411, and G431) could not be accessed directly by boat due to water depth or in-water obstructions (e.g., pilings). These stations were sampled from the shoreline below the high-water mark using a hand-held GPS unit for positioning.

Including field replicates and homogenate splits, a total of 576 surface sediment grab samples from 523 stations were submitted to analytical laboratories for chemical testing. Field replicate grabs were collected by targeting the primary grab sample coordinates. The distances between the primary and duplicate sample locations ranged from 3 to 29 ft. A detailed description of the Round 2 surface sediment collection effort is included in the Round 2 Surface and Beach FSR (Integral 2005a). Additional information is provided in the Round 2A PCB Congeners in Archived Round 2A Surface Sediment Data Report (Integral 2006a).

2.1.3.1.3 Subsurface Sediment Sampling

Subsurface riverbed sediment cores were collected at 200 locations within the lower Willamette River between RM 2 and 10 from September 20 to October 8 and from October 18 to November 11, 2004. Samples from these cores are generally referred to as subsurface samples in this report. Subsurface sediment station locations are indicated by a “C” in the station identification code (e.g., C009) on Map 2.1-17. Most of these locations were sampled to support chemical distribution in subsurface sediments; however, 49 locations also supported FS purposes, 11 locations were sampled to further support the physical CSM studies and hydrodynamic modeling effort, and 4 locations were sampled to evaluate sedimentation processes in the river.

Subsurface sediment cores were collected and processed in accordance with the Round 2 FSPs (Integral, Anchor Windward 2004; Anchor and Texas A&M 2004), the Round 2 QAPP (Integral and Windward 2004), and the Round 2 HSP (Integral 2004d). A total of 218 subsurface sediment cores were collected from the 200 stations. A total of 717 sediment samples from the cores were submitted for chemical and/or physical analyses, including 30 replicate core samples and 19 homogenate split samples. Unlike field replicate grab samples, the locations of replicate cores were deliberately shifted from the initial sampling location in order to avoid the area disturbed during the collection of the initial core. The distances between the initial and replicate core locations ranged from 1 to 43 ft. A more detailed description of the field sampling effort, including core logs, the field screening values, and photographs of the cores, is included in the Round 2A Subsurface Sediment FSR (Integral and Anchor 2005), the Round 2B Subsurface Sediment FSR (Integral 2005b), the Round 2A Archived Core Sediment Data Report (Integral 2006b) and the Round 2B Subsurface Sediment Data Report (Integral 2006c).

A subset of core segments was frozen and archived during Rounds 2A and 2B core processing for possible future chemical analysis. The Round 2B FSP Addendum for analysis of archived sediment samples (Integral 2006j) describes the process used to select for analysis of PCB congeners to supplement the paired PCB Aroclor/congener data set generated in Round 2A. A total of 53 archived Round 2 sediment samples were initially selected for PCB congener analysis. The analysis of one sample, LW2-D1-1, was subsequently canceled because it was determined that PCB congeners had previously been analyzed in this sample. Except where noted in the data report (Integral 2008a), all activities, including sample handling, processing, and data management, followed guidelines specified in the Round 2 QAPP (Integral and Windward 2004), and the Round 2 QAPP Addendum 10 (Integral and Windward 2007b).

2.1.3.1.4 Surface Water Sampling

Surface water sampling was conducted in accordance with the Round 2A FSP (Integral 2004b), the Round 2 QAPP (Integral and Windward 2004), the Round 2 QAPP Addendum 1 (Integral 2004e), and the Round 2 HSP (Integral 2004d). Surface water samples were collected in three separate events at 23 target locations from RM 2 to 11 in the Willamette River during the following time periods: November 8–December 2, 2004, March 1–17, 2005, and July 5–20, 2005. The 23 target locations included 12 amphibian habitat stations, 2 amphibian habitat/source area stations, 3 source area stations, 3 human-use contact areas, and 3 site characterization cross-sectional river transects. Map 2.1-18 shows the geographical locations for all Round 2A surface water sampling stations.

Reconnaissance Survey

Due to seasonal variations in river water levels, many overwater structures, and numerous operational waterfront industrial and port facilities in Portland Harbor, the target surface water sample locations required verification during a reconnaissance trip on the river before sampling was initiated. A reconnaissance survey took place on October 29, 2004, prior to initiation of the Round 2 surface water sampling program.

The purposes of the reconnaissance survey were to verify sampling locations, determine whether the sampling vessel could physically access each station, and to confer with agency personnel (USEPA and USFWS) on the sample locations that were selected based on the presence of amphibian habitat. Based on this reconnaissance, several target locations were modified; these changes were incorporated into the maps and tables of positional data used in the field during the fieldwork. The final sample locations are shown in Map 2.1-18.

Representatives from both the LWG and USEPA and its partners were present during the field reconnaissance survey. As indicated above, based on the reconnaissance, USEPA and the LWG agreed to modifications to the sampling approach and/or to selected sample locations, and the field crews incorporated these changes into the sampling effort. The reconnaissance survey effort was reported in the Round 2A Surface Water FSR (Integral 2005c).

Fall 2004

Surface water samples were collected at 23 target locations from RM 2 to 11 in the Willamette River from November 8 through December 2, 2004. This sampling period was targeted to coincide with the early fall rainy season. The lower than normal rainfall during the 3-week sample collection event resulted in decreasing discharge during this sample collection event and lower than historical average (1975–2003) and recent historical average (1998–2003) discharge [15,400 to 24,700 cfs] of the Willamette River for the early rainfall season. All stations identified in the FSP, including 14 amphibian habitat stations, 3 cross-sectional river transects, 3 human-use contact areas, and 3 source area stations were sampled using a peristaltic pump. Two stations (W013 and W016) were occupied twice to generate field replicates for this sampling method. In accordance with the surface water FSP and QAPP, surface water samples from all 23 target stations were submitted to analytical laboratories for chemical testing.

High-volume surface water sampling using an Infiltrex™ 300 system connected to XAD-2 resin columns was also conducted to collect hydrophobic organic compounds for analysis by ultra-low analytical methods. Sample volumes of approximately 1,000 L were collected at seven target locations in the Willamette River from November 8 through November 30, 2004. All high-volume stations identified in the FSP were sampled. One station (W013) was occupied twice to generate a field replicate for this sampling method. In accordance with the FSP and QAPP, surface water samples from all seven target stations were submitted to analytical laboratories for extraction and chemical testing. The fall 2004 surface water sampling event was reported, along with the reconnaissance survey event, in the Round 2A Surface Water FSR (Integral 2005c).

Winter 2005

The winter 2005 sampling event, conducted in early March 2005, was selected by USEPA to coincide with release of amphibian egg masses. The discharge for this event (8,390–11,900 cfs) was significantly lower than the historical average or recent historical average. From March 1 to 17, 2005, a second round of surface water samples was collected at the reoccupied stations from the fall 2004 sampling event. All 23 target stations were sampled using the peristaltic pump method. Four stations (W002, W004, W0013 and W016) were occupied twice to generate field replicates for this sampling method. Between March 1 and March 17, 2005 high-volume samples were also obtained from the seven target locations sampled during the first round. One station (W013) was occupied twice to generate a field replicate for this sampling method. Further details of the winter 2005 sampling event are documented in the Round 2A Winter 2005 Surface Water FSR (Integral 2005d).

Summer 2005

The summer 2005 surface water samples were collected from July 5 to 20, 2005 at the same stations sampled during the fall 2004 and winter 2005 sampling efforts. This low-flow sampling event was representative of typical low-flow conditions (5,720–11,300 cfs) and was consistent with historical average and recent historical average conditions for low-flow conditions. All 23 target stations were sampled using the peristaltic pump method. Two stations (W002 and W016) were occupied twice to generate field replicates for this sampling method. High-volume samples were also obtained from the seven target locations previously sampled. One station (W013) was occupied twice to generate a field replicate for this sampling method. The summer 2005 surface water sampling event is described in the Round 2A Summer 2005 Surface Water FSR (Integral 2005e).

2.1.3.1.5 Benthic Sediment Toxicity (Bioassays)

Sediment toxicity testing of Round 2 surface sediment samples (see Section 2.1.3.1.2) was performed to support the development of a predictive model(s) characterizing the relationship between sediment chemistry and benthic invertebrate toxicity in the Study Area. The 10-day *Chironomus tentans* and the 28-day *Hyalella azteca* sediment toxicity tests were conducted on 215 sediment samples collected between RM 2 and 10, and 18 sediment samples collected at stations upstream of Ross Island (~RM 16).

Surface (0–30 cm) sediment grab samples were collected at 215 stations in nearshore areas within the Portland Harbor Study Area using a power grab sampler deployed from a sampling vessel. In addition, 18 surface sediment samples were collected at six stations upstream of the Portland Harbor Study Area. A total of 11 batches of 20 sediment samples each and one batch of 13 samples for a total of 233 surface sediment samples (Map 2.1-15) were collected during Round 2 and tested in accordance with the FSP (Integral, Anchor, and Windward 2004), the Round 2 HSP (Integral 2004d), and QAPP (Integral and Windward 2004).

Field deviations from the FSP included modifications to station locations and elimination of six stations from the sampling program. There were no deviations from field procedures presented in the QAPP. Detailed descriptions of station location modifications and the USEPA approval process are presented in the Round 2 Surface and Beach Sediment FSR (Integral 2005a). Test methods and results are described in the Portland Harbor RI/FS Round 2A Data Report, Sediment Toxicity Testing (Windward 2005a).

2.1.3.1.6 Physical System Information

As part of the CSM, it is necessary to understand sediment transport regimes within the river and how they are affected under differing flow regimes. The purpose of collecting physical system information is to refine the understanding of hydrodynamic and sediment transport (HST) processes in the lower Willamette River.

There are five physical processes that may significantly affect sediment transport in the Study Area: tides, river flows, sediment inflows, sediment bed composition and dynamics (such as deposition and erosion), and wind. Density (salinity and temperature) and groundwater discharges are not included, because these processes are not expected to have a significant effect on sediment transport in the Study Area. The critical data needs for Round 2 were for sediment bed composition and sediment dynamics. Data were collected on total suspended solids (TSS) concentrations in water, suspended sediment particle-size fractions (to allow for calculation of site-specific settling velocities), and sediment bed properties (Sedflume Study). In the Sedflume Study, sediment cores were collected to measure erosion rates, critical erosion velocities, and sediment bed properties with depth. responses to high-flow events in the river). Data were collected as three major activities: TSS sampling, grain size distribution and settling velocities, and surface sediment bed properties (Sedflume Study) that are discussed below.

Except where noted in the FSR (Integral 2006e) or in the sections below, this sampling effort followed the procedures specified in the HST Modeling FSP (Integral and WEST 2006), the Round 2 QAPP (Integral and Windward 2004), the Round 2 QAPP Addendum 1 (Integral 2004e), and the Round 2 HSP (Integral 2004d). The contingent, event-based, short-term riverbed elevation surveys were not conducted because a relatively high-flow event (>100,000 cfs) did not occur following FSP approval. More detailed information regarding sampling events and results are discussed in the Round 2 HST Modeling Data Collection FSR (Integral 2006e).

Total Suspended Solids

TSS data from water samples were collected upstream over a range of flows and within the Study Area over a tidal cycle to support the hydrodynamic modeling. TSS sampling was conducted from late November 2005 to early April 2006.An upstream time series of vertically and horizontally integrated composite water samples were collected for TSS analysis to support verification of the sediment inflow–river flow rating curve (WEST and Integral 2005). Upstream TSS samples were collected from November 22, 2005 to April 5, 2006. Sampling was targeted for an upstream location well above the Study Area but below the confluence of the Clackamas and Willamette rivers (~RM 24.7) (Map 2.1-19). A total of 10 upstream TSS samples were collected at intervals triggered by changes in river flow: at 5,000-cfs intervals between 15,000 and 30,000 cfs; at 10,000-cfs intervals between 30,000 and 70,000 cfs; and, as logistically feasible, at flows exceeding 70,000 cfs, specifically at 109,000, 145,000, and 170,000 cfs. Figure 2.1-4 shows the hydrograph for the lower Willamette River (Morrison Street Bridge gauge at RM 12.8) for the November 2005 through April 2006 time period, annotated with the TSS sampling dates and associated daily mean discharge levels (cfs).

Additional Study Area TSS data were targeted to supplement TSS data previously collected as part of the Portland Harbor surface water sampling program and to support hydrodynamic model calibration and validation. Vertically integrated TSS samples were collected along four transects in the Study Area, RM 11, 6.3, and 2, and in the Multnomah Channel (Map 2.1-19), over a 2-day period on April 3 and 4, 2006. Three vertically integrated samples (west side, mid-channel, and east side) were collected along each transect. One sampling event was conducted for these locations during flows less than 30,000 cfs. During this sampling effort, two sets of TSS samples were collected over one tidal cycle, one at mid-flood and one at mid-ebb.

Suspended Sediment Grain-Size Distribution and Calculation of Settling Velocities

Measurements of *in situ* suspended sediment particle-size fractions were made to allow site-specific settling velocities to be calculated for input to the model. As described in the FSP, suspended sediment measurements were made using a laser *in situ* scattering and transmissometer (LISST)-100 system (Sequoia Scientific, Inc., Redmond, WA). The LISST-100 was deployed from a vessel and measured *in situ* suspended sediment grain-size distributions over depth and time at five target locations (Map 2.1-19). These samples were collected during the same sampling period as the Study Area TSS sampling in early April 2006.

Four of the five suspended sediment particle-size stations were located in the Study Area between RM 2 and 11 and were distributed in the mid-channel as well as along both the west and east banks. The fifth station was located in a narrow portion of the river upstream of Ross Island at approximately RM 18 (Map 2.1-19) in an effort to sample an area with potentially higher internal water shear forces.

Surface Sediment Bed Properties–Sediment Cores

Surface sediment bed properties (i.e., critical erosion velocities and erosion rates and physical sediment characteristics) were studied throughout the Study Area to provide site-specific data on these critical parameters.

Between March 28 and 31, 2006, 17 Sedflume cores (10 × 15 × 60 cm) were collected at locations throughout the Study Area (Map 2.1-19). All cores were collected by divers. Sedflume sampling locations were proximal to Round 2A core locations so that, in addition to providing site-specific erosion data for the model, these data can potentially be empirically coupled with the bulk chemistry data from each location as part of the data evaluation process. These cores were collected for the analysis of bulk sediment properties (i.e., grain size, total organic carbon [TOC], specific gravity) for comparison with the Sedflume erosion data.

2.1.3.1.7 Natural Attenuation (Radioisotope Cores)

Of the total 717 subsurface sediment core samples (see Section 2.1.3.1.3), 60 core samples were collected from sedimentation cores and submitted for 210Pb and bulk metals analyses. An additional 72 sedimentation core samples were analyzed exclusively for radioisotopes 7Be and 137Cs. Twelve samples were submitted for conventional and organics analyses in ancillary cores taken immediately adjacent to the sedimentation core at each station. The results of the sedimentation core analyses are presented in Natural Attenuation Evaluation FSR (Anchor 2005a).

The natural attenuation coring was conducted at four locations (Map 2.1-19) on October 20 and 21, 2004 using coring equipment and procedures identical to those used for the much larger Round 2 sediment sampling event that is described in the Portland Harbor RI/FS Round 2 FSP for Sediment Sampling and Benthic Toxicity Testing (Integral, Anchor, Windward 2004).

At each sampling location, two cores were taken: these cores were taken as close together as possible, while ensuring that the sediments disturbed by one core were not sampled by the second core. The first core was used for radioisotope analyses, and was termed the “radioisotope core.” The second core was sampled for ancillary information on sediment bulk chemistry and physical characteristics, and was termed the “ancillary core.” Field log forms from the core collection are contained in Appendix B of the Round 2A FSR (Integral and Anchor 2005).

The cores (in intact sections) were provided to Anchor Environmental for onshore processing (e.g., splitting and subsampling of cores) and delivery of samples to the laboratories. Core processing occurred on October 20, 21, and 22, 2004. Deviations from the FSP are discussed in the FSR (Integral and Anchor 2005).

2.1.3.1.8 Groundwater Pilot Study – Mapping Tools and Sampling Methods

From November 11, 2004 through February 8, 2005, a pilot study was performed to evaluate groundwater discharge mapping tools and transition zone sampling methods for possible use in the Round 2 GWPA. The mapping tools and sampling methods were tested offshore at three study areas: ARCO/BP Terminal 22T, Arkema Acid Plant, and Arkema Chromate Plant. The technical approach for the pilot study is presented in the GWPA Pilot Study Data Report (Appendix B in Integral 2005f). The pilot study results, in conjunction with guidance available from technical literature sources, formed the basis for the identification of methods presented in the discharge mapping FSP (Integral 2005h) and TZW FSP (Integral 2006i). All sampling was conducted in accordance with the pilot study FSP and QAPP Addendum (Integral 2004c; Kennedy/Jenks and Integral 2004). Replicate samples were also collected by each method (except the UltraSeep system) from three of the nine sampling locations (one at each study area).

The following TZW sampling tools were evaluated in the pilot study:

- Trident probe
- UltraSeep system
- Diffusion-based samplers (large- and small-volume peepers)
- Power grab sediment sampling, followed by centrifugation
- Geoprobe®.

A total of nine sampling locations were planned for collection using these methods. These sampling stations were to be distributed three per study area, with specific locations determined based on preliminary review of Trident probe discharge mapping results. To the extent practicable, collocated sampling was planned for each of the nine locations via each of the sampling methods, with the exception of the UltraSeep system. (Due to limited equipment availability and time requirements for UltraSeep sampling, the UltraSeep system was only planned for a single deployment at each of the three study areas.) The Geoprobe® was only used at the ARCO sampling location.

For groundwater discharge mapping in the study area, a combined application of two methods was recommended based on the pilot study results: temperature difference mapping using the Trident probe plus direct seepage measurements using the UltraSeep system. For TZW sampling, two of the evaluated sampling methods were recommended: push-point sampling using the Trident probe and diffusion-based sampling using small-volume peepers. A detailed discussion of discharge mapping method selection is provided in the pilot study FSP (Integral 2004c).

Thermal Infrared Imaging

Thermal infrared imaging was planned for consecutive low-tide periods, to capture daytime and nighttime images of RM 2 through 11.5. Images were successfully collected over the entire flight range for the daytime flight. For the nighttime flight, fog formed over the Willamette River downstream of the Multnomah Slough, precluding data acquisition downstream of the slough. This affected nighttime images for RM 2 and 3. A complete set of images from the thermal infrared imaging survey and a discussion of the survey results are presented in Attachment 1 to the Round 2 GWPA SAP (Integral, Kennedy/Jenks, and Windward 2005).

Trident Probe

The Trident probe groundwater discharge mapping and sampling activities were implemented as planned, with some minor deviations in response to field observations and field conditions. Trident probe groundwater discharge mapping data and samples were collected on the following dates in November 2004:

- ARCO—Mapping: November 17, 18, 22, 23; sample: November 23
- Arkema Acid Plant—Mapping: November 15–16; sample: November 19
- Arkema Chlorate Plant—Mapping: November 16, 17, 22; sample: November 20–21.

Trident groundwater discharge mapping data were collected at 64 sampling locations over the 15 transects specified in the pilot study FSP (Integral 2004c). A total of 60 locations were identified during the field planning effort for temperature and conductivity measurements with the Trident probe system (five four-point transects at each study area). All but 3 of the 60 proposed Trident probe measurements of TZW temperature and conductivity for groundwater discharge mapping were collected successfully. Additionally, seven locations were added to the scope based on real-time analysis of data. Maps 2.1-20a-l identify the Trident probe groundwater discharge mapping locations for each study area. The three points where measurements were not taken (CP08A, AP04A, and ARC01A) were all located nearshore in gravel or cobble areas. At these locations, the Trident probe could not be advanced into sediment. In each case, at least three attempts were made to deploy the probe before the location was abandoned.

Based on real-time review of field data, seven supplemental point discharge mapping measurements were made with the Trident probe system—three measurements offshore of the Arkema Chlorate Plant area and four measurements offshore of the ARCO site. In the former Chlorate Plant area, the southernmost planned transect (CP10) indicated increased subsurface conductivity measurements relative to the previous transect to the north (CP09). In response, an additional transect was added to the south (measurement locations CP11AA, CP11A, and CP11B on Map 2.1-20j) in an effort to spatially bracket the higher conductivity values. Offshore of the ARCO site, additional Trident probe measurements were obtained in the central dock area (ARC06B and ARC06C) and staggered between the northern transects in the deeper water (ARC04E and ARC05E). This was done to better characterize the apparent change in temperature trends observed between transects moving from the area south of the main dock structure to the area north of the central dock structure.

Based on a preliminary review of Trident results, a total of nine locations were selected for TZW sampling (Maps 2.1-20a-l): three from offshore of the ARCO site (ARC02B, ARC03B, ARC06B), three from offshore of the Arkema Acid Plant area (AP03B, AP04B, AP04D), and three offshore of the Arkema Chlorate Plant area (CP06C, CP07B, CP08D). An additional Chlorate Plant sampling location was added (CP10A) for the Trident sampling effort to investigate the high conductivity results in the CP10 transect; all sampling locations were at a depth of 30 cm. Additionally, a sample was collected at CP07B at 60 cm. A discussion of the basis for selection of sampling locations is presented in Attachment 2 to the Round 2 GWPA SAP (Integral, Kennedy/Jenks, and Windward 2005).

Trident Sampling Probe – Manometer

In accordance with the pilot study FSP, several attempts were made to measure groundwater head relative to surface water head by linking the manometer to the Trident sampling probe, filling the system with water, and then allowing the system to equilibrate for a reading. Five attempts were made during the pilot study to test the manometer at a variety of water depths and sediment textures. Several persistent problems prevented successful data collection. To begin, in many of the test areas, degassing from the sediment was apparent in the tubing extending to the Trident probe sampling point. In cases where degassing was present, occasional bubbles moved through the line for the entire test period (up to 1 hour). The introduction of a compressible gas moving slowly through the tubing in the closed system invalidated the head measurements.

Additionally, in areas of fine sediments, significant suction from the peristaltic pump was needed to draw water up from the sediment to fill the manometer. As a result, fine sediment often packed around the intake, thereby changing the local hydraulic conductivity of the surrounding sediments and likely obscuring the reading. Furthermore, with the high suction required, leaks in the system arose at connections on the manometer, requiring frequent seal replacement.

In coarser sediments, where there were no complications from leakage or degassing, the pressure differential signal was still not clear. Motion of the boat and the float leading to the surface water line caused the readings to fluctuate, overwhelming the signal, and suggesting the signal was probably small.

UltraSeep System

During the pilot study, the UltraSeep system was programmed to collect continuous flow data and multiple samples from each sample station over the course of 24 hours. A W.S. Ocean Systems (now EnviroTech) ESM data logger/controller unit was used to monitor data from the flow meter.

All operational activities relating to the UltraSeep systems were performed by Coastal Monitoring Associates with oversight by Integral Consulting personnel. The UltraSeep system could not be deployed at the ARCO site due to conflicts with barge schedules, which precluded two consecutive days of assured access for deployment and retrieval. The system was deployed at three Trident probe groundwater discharge mapping locations at the Arkema site: one in the Chlorate Plant area (CP07B; Map 2.1-20j) and two in the Acid Plant area (AP04B and AP04D; Map 2.1-20j).

Following deployment, the UltraSeep was left in place for approximately 24 hours. The system was pre-programmed to continuously log flux measurements at 5-minute intervals at station AP04D, and 12-minute intervals at AB04B and CP07B. The system was also programmed to collect samples in time-series sampling bags, in response to positive flux measurements. Sample grab volumes matched the positive flux measurements, producing a sample equal in volume to the observed positive flux over the deployment period.

The UltraSeep unit was deployed and retrieved on the following dates:

- Arkema Acid Plant (AP04D)—Deployed November 10 and retrieved November 20, 2004
- Arkema Acid Plant (AP04B)—Deployed November 23 and retrieved November 24, 2004
- Arkema Chlorate Plant (CP07B)—Deployed November 21 and retrieved November 22, 2004.

Groundwater level data were also collected at 15-minute intervals by pressure transducers deployed in two nearshore wells at the Arkema site during deployments of the UltraSeep (MWA-10i and MWA-32i, see Appendix A-7 of the SAP, Figure 3). These measurements allowed for contemporaneous monitoring of upland groundwater levels and groundwater discharge rates in response to the tidal cycle.

Due to the low groundwater discharge rates, sample volumes were small, limiting analyte lists. At AP04D, the discharge was consistently negative or zero, thereby producing no sample for analysis. At AP04B, a total of 100 mL were collected (80 mL submitted to lab in two volatile organics vials). At CP07B, a total of 754 mL were collected. Analytical results for sampling stations CP07B and AP04B, including field and laboratory replicates, are presented in the Pilot Study Data Report (Appendix B of Integral 2005f).

Diffusion-Based Samplers – Peepers

Both large- and small-volume diffusion-based samplers (i.e., peepers) were deployed at the nine TZW sample locations selected during the discharge mapping phase. For the most part, sample collection with the diffusion-based samplers followed the pilot study plans specified in the FSP.

A total of 30 small-volume peepers were available for the pilot study, and one peeper was damaged during attempted deployment; the number of samplers deployed at each location depended on the desired analyte list (volume constraints), whether a replicate was being collected, and other constraints on the number of sampling devices. All samplers were positioned in the upper 30 cm of the sediments, and left in place for a period of 3 weeks to allow for equilibration with TZW.

Deployment and retrieval occurred on the following dates:

- ARCO—Deployed December 20, 2004 and retrieved January 10, 2005
- Arkema Acid Plan—Deployed December 21–22, 2004 and retrieved January 11–12, 2005
- Arkema Chlorate Plant—Deployed December 21, 2004 and retrieved January 11, 2005.

Power Grab Sediment Sampling and Centrifugation

The power grab sampler was used to collect bulk sediment samples from the upper 30 cm of sediment. TZW samples were extracted from the power grab bulk sediment samples by centrifugation. The remaining, uncentrifuged sediment subsamples were used for analysis of bulk sediment chemical concentrations.

Bulk sediment samples were collected from the upper ~30 cm of sediment at each of the nine sampling locations using a power grab sampler. Bulk sediment sample collection was completed on the following dates at each site:

- ARCO—January 21, 2005
- Arkema Acid Plant—January 18–19, 2005
- Arkema Chlorate Plant—January 19, 2005.

Geoprobe

Direct-push sampling of shallow groundwater was performed at three sampling stations at the ARCO site using a barge-mounted Geoprobe® drill rig on February 7–8, 2005. The purpose of this sampling was to assist in the validation and interpretation of the findings of the pilot study groundwater discharge mapping and TZW sampling by 1) determining whether contaminants of interest (COIs) are present in groundwater within the groundwater discharge zone targeted for TZW sampling, and 2) assisting in the determination of the origin of COIs detected in the TZW (i.e., transported to TZW via discharge of contaminated groundwater versus desorbed into TZW from contaminated sediments). Borehole total depths were 40 ft for ARC02B and 15 ft for both ARC03B and ARC06B (Map 2.1-20e).

2.1.3.1.9 Groundwater Pathway Assessment

The Round 2 GWPA was performed to support evaluation of the potential risk to in-water receptors resulting from groundwater plume discharges to the Study Area.

The objective of Round 2 TZW sampling was to collect and analyze samples of TZW to quantify concentrations of groundwater-related COIs in areas of plume discharge identified during the groundwater discharge mapping field effort. Additionally, sediment samples were collected at a subset of locations to support sediment–water partitioning analysis.

The Round 2 GWPA sample collection by the Trident probe, small-volume peeper, and power grab sampling techniques was performed between October 3 and December 2, 2005. Except where noted in Section 4 of the FSR (Integral 2006f), all Round 2 GWPA sampling activities, including navigational positioning, sample collection, sample handling and processing, and data management, followed guidelines specified in the following planning documents:

- Round 2 GWPA SAP (Integral 2005f)
- SAP Attachment 2, TZW FSP (Integral 2005i)
- TZW FSP Addendum 1 (Integral 2005j)
- TZW FSP Addendum 2 (Integral 2005k)
- TZW FSP Annotated Cross Sections (Integral 2005l)
- Round 2 QAPP Addendum 3 (Kennedy/Jenks and Integral 2004)
- Round 2 QAPP Supplement to Addendum 3 (QAPP supplement; Integral 2005n)
- Round 2 GWPA HSP (Integral 2005m).

Deviations from these documents in the field were primarily limited to access issues at the Gasco site and anticipated volume limitations in TZW sampling.

As described in the SAP (Integral, Kennedy/Jenks, and Windward 2005), the following nine sites were included in the Round 2 TZW sampling effort:

- ExxonMobil Oil Terminal
- Gasco
- Siltronic
- Arkema Acid and Chlorate Plant
- Kinder Morgan Linnton Terminal
- ARCO Terminal 22T
- Rhone Poulenc (Bayer)
- Willbridge Bulk Fuels Terminal
- Gunderson.

A total of 191 TZW samples, including replicate samples and paired filtered samples, were successfully collected at 80 locations using the Trident probe and small-volume peepers. Of these 191 samples, 155 samples were collected by the Trident probe and the remaining 36 samples were collected by small-volume peepers. Of the Trident probe samples, 117 were collected at 30 cm depth below the mudline (bml) and 38 were collected at 90 to 150 cm depth bml. Paired filtered samples were collected at 78 percent of the target Trident samples, resulting in 57 percent collection of paired filtered samples across the target TZW sampling effort. Sampling of TZW by small-volume peepers was performed at all study sites except ExxonMobil, where the Trident successfully collected all targeted samples.

The 36 sets of small-volume peepers were deployed in two mobilizations and, following equilibration, were retrieved in two subsequent mobilizations. The first peeper deployment took place October 17 through 20, 2005. Seventeen sets of peepers (a total of 89 individual small-volume peeper devices) were installed during this first deployment offshore of the ARCO, Siltronic, and Arkema (former Acid Plant and Chlorate Plant areas) sites. The peepers were allowed to equilibrate for 3 weeks, and then retrieved between November 14 and 18, 2005. The second deployment mobilization took place October 31 through November 3, 2005. Nineteen sets of peepers (a total of 78 individual small-volume peeper devices) were deployed during this phase offshore of the Kinder Morgan, Gasco, Rhone Poulenc, Willbridge, and Gunderson sites. The peepers were allowed to equilibrate for 3 weeks, and then retrieved between November 28 and December 1, 2005. Of the 36 sets of small-volume peepers deployed, nine were replicates (one replicate pair was deployed at each site where peeper sampling was performed).

At total of 38 bulk sediment samples were collected from 34 locations using the power grab sampler across the nine study sites, with two to six locations sampled at each site. Of these, four were replicate samples. An overall summary of samples collected at each site, and tabular and graphical summaries of all collected samples and requested analyses are presented by site in of the FSR (Integral 2006f).

2.1.3.1.10 Subyearling Chinook Salmon Tissue

This sampling effort was intended to supplement the baseline ecological data related to potential exposure of juvenile Chinook salmon (*O. tshawytscha*) to site-related contaminants. The objectives of this study were to 1) determine the extent to which subyearling Chinook salmon in the Portland Harbor area may accumulate COIs, and 2) estimate exposure of subyearling Chinook by characterizing COI concentrations in stomach contents.

Two site reconnaissance surveys were undertaken on April 11 and May 9, 2005, prior to initiation of the Round 2 subyearling Chinook salmon tissue collection. While the results of the first reconnaissance trip determined that the subyearling salmon collected would not meet the minimum size requirements, the second reconnaissance trip confirmed the presence of fish that met the target size requirements, and sampling was initiated the following day.

Subyearling Chinook tissue samples were collected at four target locations from May 10 to 12, 2005, including three stations within the ISA and one station upriver, along with one field replicate. A detailed description of the fish sample collection, dissection, and sample processing is provided in the FSR (Integral and Windward 2005a). The Round 2 Subyearling Chinook Tissue Data Report summarizes the results from this sample collection effort (Integral and Windward 2006a).

Except where noted in the FSR (Integral and Windward 2005a), all Round 2 subyearling Chinook tissue collection field activities, including navigational positioning, sample collection, sample handling and processing, and data management, followed guidelines specified in the following documents:

- Portland Harbor RI/FS Field Sampling Plan for Subyearling Chinook Tissue Collection (Chinook Tissue FSP; Integral, Windward, and Ellis 2005)
- Round 2 QAPP (Integral and Windward 2004)
- Round 2 QAPP Addendum 4: Subyearling Chinook Tissue Collection (Integral 2005o)
- Round 2 QAPP Supplement to Addendum 4: Subyearling Chinook Tissue Collection – Semivolatile Organic Compounds (Integral 2005p)
- Round 2 HSP (Integral 2004d).

Subyearling Chinook tissue samples were collected at four target locations in the Willamette River from RM 2 to 18 (Map 2.1-10). All stations identified in the FSP, including three stations within the Study Area and one station upriver from the ISA, were sampled. One station (T03) was occupied twice on subsequent days to collect enough fish to generate field replicates for chemical analyses.

Only target subyearling Chinook salmon (i.e., fish within the 50- and 80-mm target length) were retained for sampling; all other fish were returned to the river. A total of 95 fish were captured, to obtain three 30-fish composite sample replicates for chemical analyses, and at least five additional fish for taxonomical analyses of stomach contents.

The live juvenile subyearling Chinook were transported to the LWG's Portland field laboratory for further sample processing. The standard chemical suite for whole-body fish tissue included percent lipids, percent moisture, total metals, butyltin compounds, organochlorine pesticides, polycyclic aromatic hydrocarbons (PAHs), semivolatile organic compounds (SVOCs), dioxins and furans, and PCB congeners (full list of 209 congeners). The stomach (gut) contents of five to eight individuals from each fish composite were separated for identification and enumeration of prey species. The remaining stomach contents were analyzed for PAHs, PCB congeners (full list of 209 congeners), and organochlorine pesticides. In addition to the fish tissue samples collected by the LWG, NOAA collected fish at Stations T01 and T02 for stomach content analysis. NOAA performed the dissection and provided LWG with the stomach contents for analysis. The FSR (Integral and Windward 2005a) summarizes the results for taxonomical analyses of 20 fish stomach samples collected at the three sampling stations, T01, T02, and T04 (Map 2.1-10). A total of 36 prey organisms were identified in the 20 subyearling chinook stomachs. The most commonly identified prey organisms belonged to six taxonomical groups. Cladocera (daphnids) accounted for 57.5 percent of all prey organisms identified in the stomachs. The high percentage was to a large extent driven by one juvenile Chinook having eaten 358 daphnids out of 906 identified prey organisms. Daphnids were found in 30 percent of the 20 stomachs. Chironomids (blood worms) were identified in 60 percent of the stomachs and accounted for 8.9 percent of all identified organisms. The other four commonly identified organisms included Coleoptera (beetles, 12.6 percent of all identified organisms), Nematocera (long-horned flies, 5.1 percent of all identified organisms), and Psocoptera (wood lice, 2.8 percent of all identified organisms). The developmental stages of the insects identified in all stomach contents samples were 73 percent larvae, 2 percent pupae, and 25 percent adults.

2.1.3.1.11 Multiplate Epibenthic Invertebrate Tissue

Epifaunal invertebrates were collected using multiplate samplers in the spring/summer of 2005 to provide information on invertebrate exposures in the water column. Invertebrates were collected at surface water sampling locations distributed throughout the Study Area. The multiplate samplers were located in a variety of habitats adjacent to riprap, on sandy beaches, and in soft-bottom quiescent areas.

The specific objectives of the Portland Harbor invertebrate sampling using multiplate samplers were as follows:

- Measure constituents in invertebrate tissue samples that represent epibenthic organisms within the Study Area for use in the BERA fish, bird, and mammalian exposure models.
- Measure constituents in invertebrate tissue samples that represent epibenthic organisms within the Study Area for use in the tissue-residue line-of-evidence for benthic risk in the BERA.
- Measure constituents in invertebrate tissue samples that represent epibenthic organisms within the Study Area for use in the food web model to develop risk-based cleanup goals. It was anticipated that the multiplates biomass would represent accumulation via the surface water pathway.

Multiplate samplers were placed at 10 locations (Map 2.1-5) within the Study Area between RM 2 and 11, between July 26 and 28, 2005. Members of the regulatory agencies and trustees were present on July 26, 27, 28, and September 7, 2005, to oversee field operations. Observers were Jennifer Peterson and Mikeel O’Mealy from Oregon DEQ and Eric Blishke from USEPA.

Sampling procedures for collection of invertebrates using multiplate samplers followed those detailed in the FSP (Windward and Integral 2005b,c), the Round 2 QAPP

(Integral and Windward 2004), and QAPP Addendum 5 (Integral 2005q). The Round 2 Multiplate Invertebrate Tissue Data Report (Integral 2006h) summarizes the results from the July through September 2005 sample collection effort designed to supplement the Round 1 multiplate tissue data set.

The multiplate samplers were deployed at the 10 stations. At each station, 4 arrays of 6 multiplate samplers (total of 24 multiplate samplers per station) (Figure 2.1-2) were deployed based on field determination of the most suitable location for each array. Factors included in the suitability evaluation included water depth (at least 5 m to ensure adequate water depth later in the summer), tie-up point for the rope connected to the array, avoiding high traffic areas and prop-wash areas, and avoiding the dredge operation near Gasco. Six of the stations were placed at a distance of 92 m or less from the proposed locations. The remaining 4 stations where placed further away (148 to 236 m) from the proposed locations because of the reasons mentioned above. Prior to deployment the multiplate samplers were washed with a brush and Alconox™.

On Monday, August 15, two of the sampler arrays at station MIT005 were reported damaged near the Rhone Poulenc outfall diffuser. The damaged arrays were retrieved on August 15 and 17 and replacement samplers were deployed just downstream of the remaining two samplers at MIT005 on Thursday, August 18. On August 31, one sampler array from station MIT002 was observed on the shore without anchors, and buoys from another array were observed at the surface of the water. On September 1, the array on the shore was attached to new anchors and redeployed in the original location. The other array with buoys at the surface was left untouched. The multiplate samplers were retrieved at all locations between September 6 and 15, 2005.

The multiplate samplers were retrieved approximately 6 weeks later. All sampler arrays were retrieved at all stations except at stations MIT007 and MIT002. At MIT007, 1 array of 5 samplers and 1 single sampler on another array were missing (a total of 17 samplers were retrieved for analysis). At MIT002, 1 array of 6 samplers was missing and another array of 6 samplers was lying in shallow water on the sediment with the weights cut off (a total of 12 samplers were retrieved for analysis).

At all stations, except MIT002 and MIT007, 21 multiplate samplers were sent to a laboratory and processed for invertebrate tissue analyses. At MIT002 and MIT007, only 10 and 16 multiplate samplers, respectively, were processed for tissue analyses. The remaining 3 multiplate samplers from each station (only 1 from MIT002 and 2 from MIT007) were processed for taxonomic evaluation.

Following retrieval, the 14 tempered hardboard plates were removed from each sampler in the laboratory and the organisms from each plate were picked or scraped off using stainless steel forceps and placed either in a small stainless steel sieve or into a clean glass jar filled with site water. (Some of the organisms were retained in a clean jar with site water because they were very lively and would crawl out of the sieve before all the plates from one station were processed.) The organisms were sorted into the following major groups: crustaceans (predominately *Corophium sp.*), insect larvae (predominantly chironomids), bryozoans and sponges, mollusks, invertebrate eggs, and miscellaneous taxa (worms and others), and fish eggs. After all the retrieved multiplate samplers from one station were processed, the remaining debris/mud in the glass jar(s) was examined under a dissecting microscope and missed organisms were picked out. Daphnids swimming in the water phase were strained out by pouring the water through a small stainless steel sieve. Then, each major invertebrate group was weighed, except Daphnids, because they were too small and there was a likelihood of losing a significant portion of them in the weighing process.

Because of the limited number of tissue samples from all stations, a revised chemical analytical approach was developed in cooperation with USEPA and its partners. This revised analytical approach is described in a supplement to the multiplate tissue QAPP Addendum 5 (Integral 2005) and includes combining tissue samples from several stations to achieve sufficient mass for chemical analysis. The tissue samples were homogenized and analyzed for PCBs, DDTs, PAHs, phthalates, metals, lipids, and moisture.

A detailed description of the Round 2 multiplate tissue collection effort is included in the FSR (Windward 2005b).

2.1.3.1.12 Reconnaissance for Benthic Invertebrates and Clam Tissue

The specific objectives of the Portland Harbor Round 2 benthic invertebrate and clam tissue sampling effort were as follows:

- Measure constituents in benthic invertebrate tissue samples that represent benthic invertebrate prey organisms within the Study Area for use in the BERA fish, bird, and mammalian dietary exposure models. It was expected that clams would be the predominant biomass and would be a surrogate for other species.
- Measure constituents in benthic invertebrate tissue samples that represent benthic organisms within the Study Area for use in line-of-evidence in the BERA.
- Measure constituents in benthic invertebrate tissue samples that represent benthic organisms within the Study Area for use in calibrating the food web model.
- Use information from both field-collected and laboratory bioaccumulation tests to calculate a site-specific biota-sediment accumulation factor.

The benthic sledge, bongo net, diaphragm pump, and Schindler trap were all evaluated as potential sampling approaches for collecting sufficient tissue for invertebrates predominantly exposed through sediment (Windward 2005c). Based on this effort, it was determined that the use of the benthic sledge in locations throughout the Study Area for collecting clams (*Corbicula sp.*) would provide the best opportunity to collect the mass of tissue required to meet analytical goals. Bioaccumulation testing would be conducted on freshwater oligochaetes (*Lumbriculus variegatus*) to estimate tissue concentrations for other common sediment-exposed benthic invertebrates. Bioaccumulation testing would also be conducted using *Corbicula fluminea* to facilitate the evaluation of the two difference exposure regimes (field and lab) and the subsequent tissue concentrations.

Using a benthic sledge, clams (*Corbicula* sp.) were sampled at 33 sample locations (Map 2.1-21) between RM 2 and 10 between November 28 and December 14, 2005. Sampling procedures for the collection of clams followed those detailed in the Portland Harbor RI/FS FSP: Round 2 Sampling of Benthic Invertebrate Tissue (Windward and Integral 2005b), the Round 2 QAPP (Integral and Windward 2004), the Round 2 QAPP Addendum 2: PCB Congener Analysis in Sediment Samples (Integral 2004f) and the Round 2 QAPP Addendum 6: Sampling of Benthic Invertebrate Tissue (Integral and Windward 2005b). As stated in the FSP, all mussels and lamprey ammocoetes collected at the 33 stations were retained for possible chemical analysis. The Round 2 Benthic Tissue and Sediment Data Report (Integral and Windward 2006b) summarizes the results from the November through December 2005 sample collection effort designed to supplement the Round 1 benthic invertebrate tissue chemistry data set. A detailed description of the Round 2 benthic invertebrate and sediment collection effort is included in the Round 2 Sampling of Benthic Invertebrate Tissue FSRs (Windward and Integral 2005a, 2006). Except where noted in the FSR, all Round 2 benthic invertebrate collection field activities, including navigational positioning, sample collection, sample handling and processing, and data management, followed guidelines specified in the approved FSP and QAPPs.

Members of the regulatory agencies and trustees were present on November 28, 29, and 30, 2005, and on December 1, 5, 6, 7, 8, 9, 12, 13, and 14, 2005, to oversee field operations. Observers were Jennifer Peterson from the Oregon DEQ, Joe Goulet and Eric Blishke from USEPA, Jeremy Buck and Mike Szumscki from the USFWS, Chris Thompson and Aron Borok from Environmental International Ltd., and David Gillingham, Andrew Somes, and Jessie Bennett from Parametrix, Inc.

Of the 33 sampling locations, 20 were located along the shoreline of the main lower Willamette River channel and 12 were located in off-channel slips or embayments. The remaining station was located in Multnomah Channel. Twenty-three of the sampling locations were also within sandpiper foraging habitat. All sampling locations were in areas where elevated concentrations of at least one chemical were measured in the Round 2 surface sediment sampling effort.

The benthic invertebrate tissue sampling effort was conducted as a series of sampling events. The first event was the field collection of clams. The collection was initiated November 28, 2005. A week later, on December 5, 2005, sediment collection was initiated by sampling at stations where the collection of clams had been completed. The sediment sampling at each station used a location-specific sampling approach, which was based on locations where clams had been successfully collected. Sediment was collected for both chemical analysis and bioaccumulation testing with two organisms, the clam *Corbicula fluminea* and the worm *Lumbriculus variegatus*. The clam sampling effort at the 33 locations (Map 2.1-21) was completed on December 14; and the sediment sampling effort was completed on December 20, 2005.

Sufficient amounts of tissue were collected for a full suite of chemical analyses, including percent lipids, PCB congeners, PAHs, organochlorine pesticides, butyltin compounds, phthalates, SVOCs, metals, and dioxins and furans. Laboratory bioaccumulation testing was conducted with the sediments using freshwater oligochaetes (*Lumbriculus variegatus*) to estimate tissue concentrations for other common sediment-exposed benthic invertebrates. Bioaccumulation testing was also conducted using *Corbicula fluminea* to allow evaluation of the two different exposure regimes (field-collected and laboratory-exposed) and the subsequent tissue concentrations.

2.1.3.1.13 Mussel and Lamprey Ammocoete Tissue

Sampling of lamprey ammocoetes and mussels was conducted concurrently with the sampling for clams (*Corbicula* sp.) discussed in the previous section. The sampling was conducted at 33 locations within the Study Area (Maps 2.1-5 and 2.1-11) between RM 2 and 10 in November and December 2005.

In accordance with the Round 2 Sampling of Benthic Invertebrate Tissue FSP (Windward and Integral 2005b), all lamprey ammocoetes and mussels collected at the 33 locations (Maps 2.1-5 and 2.1-11) were retained for possible chemical analysis. The mussel and lamprey ammocoete samples were handled in a manner similar to that of the clam samples. One to two lamprey ammocoete individuals were collected at nine locations; a total of 10 lamprey ammocoetes were collected. A total of 40 mussels were collected at 19 locations with numbers ranging between 1 and 7 individuals. The majority of the mussels were tentatively identified as Western pearlshell mussels (*Margaritifera falcata*); only a few individuals (5) collected at BT007 and BT009 were tentatively identified as winged floaters (*Anodonta nuttalliana*).

Chemical analysis was performed on the composite lamprey ammocoete sample and seven mussel tissue samples collected at stations BT001, BT004, BT006, BT009, BT021, BT025, and BT033. Chemical analysis was not conducted on two of the mussel samples because the sample collected at BT017 consisted of one mussel that turned out to be an empty shell and the other sample collected at BT015 consisted of only one mussel. The Round 2 Mussel and Lamprey Ammocoete Tissue Data Report (Windward and Integral 2007) summarizes the results from the Round 2 sample collection effort.

2.1.3.1.14 Cultural Resources Analysis

According to CERCLA and its implementing regulations, USEPA is required to comply with federal statutes that provide protection for archaeological and historical resources, including Native American burials and places of traditional religious and cultural significance. In 2001, USEPA and Oregon DEQ signed a Memorandum of

Understanding (MOU) with six tribal governments and three federal and state agencies that identified cultural resources as an area of special concern to the signatory tribes. Also in 2001, USEPA signed an AOC with the LWG to perform a cultural resource survey as part of the RI/FS. The survey included the in-water portion of the Site from the confluence of the Willamette and Columbia rivers to Willamette Falls, including upland areas adjacent to this stretch of the river. Results of the survey are documented in Cultural Resource Analysis Report for the Portland Harbor Superfund Site, Portland, Oregon (AINW 2005). A comprehensive cultural resource analysis, including procedures for protecting and addressing cultural resources before, during, and after the RI/FS and remedial design is complete, will be provided in consultation with the tribes at a later date.

2.1.4 Round 3 RI Field Investigations (2006–2008)

Round 2 sampling focused on sediment and surface water chemistry, benthic toxicity, and ongoing work related to site characterization within the currently identified Portland Harbor Study Area. The Round 3 sampling needs included collection of additional data to complete the site characterization, refine the CSM, complete the BERA and BHHRA, and support the FS. The data gaps that needed to be completed in Round 3 sampling were identified in the Round 3 SOW (USEPA 2006b) and the Comprehensive Round 2 Site Characterization Summary and Data Gaps Analysis Report (Integral, Windward, Kennedy/Jenks, and Anchor 2007).

Round 3 field investigations were performed from January 2006 through January 2008. Round 3 field investigations are discussed in the following FSRs or data reports:

- Surface water (Integral 2006k,l,m , 2007a,b,c,d)
- Groundwater – Gunderson Site (Integral 2007e)
- Stormwater (Anchor and Integral 2007a, 2008a,b)
- Lamprey ammocoete tissue (Windward 2006a, 2007a, 2008a; Integral and Windward 2007a)
- Sturgeon tissue (Windward 2007b; Windward and Integral 2008)
- Fish and invertebrate tissue and collocated surface sediment (Integral and Windward 2008; Integral 2008b,c)
- Sediment – Willamette Cove (Integral 2008d)
- Sediment and sediment toxicity bioassays (Integral 2008e,f; Windward 2008b)
- Sediment trap (Anchor 2007a,b,c, 2008a; Anchor and Integral 2008a,b,c)
- Upstream/downstream surface and subsurface sediment (Integral 2007f,g)
- Natural attenuation (radioisotope subsurface sediment cores) (Integral 2007f,h)
- Sediment chemical mobility testing (Anchor and Integral 2008d; Integral 2009)
- Side-scan sonar (Anchor QEA 2009a).

Except where noted in the FSRs, the data reports, or as modified by subsequent correspondence between the LWG and USEPA, all sample collection activities followed the procedures described in the following Round 3 FSPs and SOPs:

- Surface water (Integral 2004b, 2006n,o,p)
- Groundwater – Gunderson Site (Integral 2007i)
- Stormwater (Anchor and Integral 2007b,c)
- Lamprey ammocoete tissue (Windward 2006b,c; LWG 2006)
- Sturgeon tissue (Windward 2007c; Integral 2007j)
- Fish and invertebrate tissue and collocated surface sediment (Integral 2007k)
- Sediment – Willamette Cove (Integral, Anchor, and Windward 2004)
- Sediment and sediment toxicity bioassays (Windward 2007d; Integral, Windward, and Anchor 2007a,b; Integral 2007l; Integral and Anchor 2007)
- Sediment trap (Anchor 2006b)
- Upstream/downstream surface and subsurface sediment (Integral 2006q)
- Natural attenuation (radioisotope cores) (Integral 2006q)
- Sediment chemical mobility testing (Anchor 2008b)
- Side-scan sonar (Anchor 2008c).

All field sampling was conducted in accordance with the following HSPs:

- Round 2 HSP (Integral 2004d)
- Round 2 GWPA HSP (Integral 2005m).

All laboratory analyses follow the following USEPA-approved Round 2 QAPPs:

- Round 2 QAPP Addendum 1: Surface Water (Integral 2004e)
- Round 2 QAPP Supplement 1 to Addendum 1: Round 3A Surface Water Sampling (Integral 2006r)
- Lamprey Ammocoete (*Lampetra* sp.) Toxicity Testing QAPP (Windward 2006d)
- Round 2 QAPP Addendum 7: Round 3 Chemical Analysis of Lamprey Ammocoete Toxicity Test Water (Integral 2006s)
- Round 2 QAPP Addendum 8: Round 3A Stormwater Sampling (Integral 2007m)
- Round 3 Lamprey Ammocoete (*Lampetra* sp.) Toxicity Testing QAPP Addendum: Phase 2 Lamprey Ammocoete Collection and Testing (Windward 2007e)

- Round 2 QAPP Addendum 9: Fish and Invertebrate Tissue and Co-located Sediment Sampling for Round 3B (Integral 2007n)
- Round 2 QAPP Addendum 10: Round 3B Comprehensive Sediment and Bioassay Testing (Integral and Windward 2007b)
- Round 2 QAPP Addendum 11: Sediment Chemical Mobility Testing (Integral 2008g).

2.1.4.1 Summary of Round 3 Field Activities

The purpose of the Round 3 sample collection was to provide greater specificity regarding the nature and scope of data collection efforts necessary to address the existing data gaps, and to support the RI/FS and subsequent cleanup decisions.

The specific Round 3A objectives can be related to specific data analyses within the RI/FS as follows:

- **Nature and Extent of Surface Water Chemicals**. Acquire additional low detection limit data under specific flow and runoff conditions to augment the Round 2A data. Refine the CSM, and support the fate and transport modeling effort, which is currently under development.
- **Food Web Model**. Consider additional surface water chemistry data for use with Round 2A data, as appropriate, to characterize average chemical concentrations in surface water for use in the food web model. In addition, data for a wider range of flow conditions will be considered for characterizing seasonal and event-specific (e.g., storm) variability of chemical concentrations.
- **Background Conditions/Site Boundary**. Collect water quality data upstream of the ISA to assist in characterization of background conditions and, along with other information, help define the boundaries of the Site.
- **Source Identification**. Collect data to help understand the regional impact of any ongoing sources to the Site and to differentiate between sediment resuspension and other potential sources.
- **Feasibility Study**. Collect water quality data to support development of the FS objectives, including evaluation of remedial alternatives as they relates to fate and transport of chemicals, background conditions, source characterization/recontamination issues, and the potential for monitored natural recovery.
- **Hydrodynamic/Sediment Transport Model**. Collect TSS data to further refine and calibrate the HST model.

The 2006/2008 Round 3 Portland Harbor RI field sampling efforts include collection of the following information:

- Surface water

- Groundwater – Gunderson Site
- Stormwater
- Lamprey ammocoete tissue
- Sturgeon tissue
- Fish and invertebrate tissue and collocated surface sediment
- Sediment – Willamette Cove
- Sediment and bioassay
- Sediment trap
- Upstream/downstream surface and subsurface sediment
- Natural attenuation (radioisotope cores)
- Sediment chemical mobility testing
- Side-scan sonar.

2.1.4.1.1 Surface Water

The Round 3A surface water investigation was conducted to supplement the results of the Round 2A surface water investigation. Surface water chemistry was measured under various flow conditions and at additional locations upstream and downstream of the Study Area in Round 3A. The primary objectives of the Round 3A surface water sampling effort were as follows:

- Assess water quality conditions in the Study Area and adjacent areas under various flow conditions
- Collect data to support the FS evaluation of remedial alternatives, including monitored natural recovery, potential recontamination of sediment surface from surface water, and background conditions
- Continue to evaluate nature and extent of chemicals in surface water
- Refine the CSM
- Provide additional water quality data to further support the food-web modeling effort for the ecological and human health risk assessments.

These surface water field activities were conducted in accordance with the Round 3A Surface Water FSP (Integral 2006n), the Addendum to Round 3A FSP Summer Low-Flow Surface Water Sampling (Integral 2006o), Round 3A FSP Surface Water Sampling Addendum 2 (Integral 2006p), the Round 2A Surface Water FSP (Integral 2004b), the HSP (Integral 2004d), the QAPP (Integral and Windward 2004), the Round 2 QAPP Addendum 1 for Surface Water Sampling (Integral 2004e), and the Round 2 QAPP Supplement 1 to Addendum 1: Round 3A Surface Water Sampling (Integral 2006r). Deviations from the planned approaches are described in the FSRs (Integral

2006k,m, 2007b,c) and were generally coordinated with the USEPA team prior to their implementation.

For Round 3A, both transect and single-point samples were collected, and both peristaltic and hydrophobic polyaromatic resin (XAD) methods were used at selected stations (Map 2.1-18). Round 3A sampling locations included three Round 2A transect stations (RM 11, 6.3, and 4), three additional transects (RM 16, 2, and at the inlet to the Multnomah Channel), and 12 single-point locations between RM 2 and 10. At RM 2 and 11, the transects were subdivided into three lateral segments across the river as follows: east shoreline to navigational channel, navigational channel, and navigational channel to west shoreline, resulting in a total of six stations for these two transects. Surface water was collected at the Round 3A surface water locations during the following four sampling events. The sample collection for each of the four events is described below:

January 2006 High-flow Event
This event, conducted January 19–21, consisted of the collection of single-point mid-river peristaltic and XAD samples at two Round 2A stations (W023 at RM 11, W005 at RM 4) and one Round 3A location (W024 at RM 16) during flood conditions (Q>160,000 cfs).

Surface water samples were collected using a peristaltic pump at three mid-channel target locations at RM 4, 11, and 16 in the Willamette River (Map 2.1-18) using an Infiltrex 300 system connected to XAD-2 resin columns to collect hydrophobic organic compounds for analysis by ultra-low analytical methods. All stations identified in the FSP (Integral 2006m) were sampled. One station (W023) was occupied twice to generate a field replicate for the peristaltic sampling method. A field replicate was not collected during this sampling event for the XAD method.

River stage and river flows on the Willamette River at Portland as well as local precipitation levels that occurred during the surface water sampling period (January 19–21, 2006) are shown in the FSR (Integral 2006k).

September 2006 Low-flow Event
Surface water samples were collected September 4–13 from six transect locations between RM 2 and 16 (Map 2.1-18). This event was conducted during low-flow conditions (Q<20,000 cfs) by collecting near-bottom and near-surface (NB/NS) peristaltic and XAD samples at four transect locations (W005 at RM 4, W011 at RM 6.3, W024 at RM 16, and W027 in Multnomah Channel), and by collecting vertically integrated samples at three stations spaced laterally across the river at two Round 3A transect locations (W023 at RM 11 and W025 at RM 2). All stations identified in the Round 3A Surface Water FSP were sampled; however, the field replicate transect sample (W011) scheduled for September 15, 2006 was not collected because rain had fallen the day before (0.13 inch on September 14, 2006).

Vertically integrated water column samples were collected using both peristaltic pump and Infiltrex pump methods at two transect locations (W025 at RM 2 and W023 at RM 11). Each transect was subdivided into three lateral segments across the river as follows: east shoreline to navigational channel, navigational channel, and navigational channel to west shoreline. These lateral segments were sampled at the midpoint of each segment; the navigation channel sample was collected as close to mid-channel as feasible. At the midpoint of each segment, a vertically integrated water column sample was collected. Details on the transect sampling approach are provided in Appendix G of the Round 3A Surface Water FSP (Integral 2006n).

River stage and river flows on the Willamette River at Portland, as well as local precipitation during the surface water sampling period (September 4–13, 2006), are shown in the FSR (Integral 2006m).

November 2006 Stormwater Event

This event was conducted November 2–5 during a stormwater runoff event when the river discharge is in low-flow conditions (Q<20,000 cfs) by collecting NB/NS peristaltic samples and XAD samples at 18 Round 3A locations (Map 2.1-18) during an active stormwater event(s).

Cross-sectional near-bottom and near-surface peristaltic and high-volume samples were collected at four transect locations (W005 at RM 4, W011 at RM 6.3, W024 at RM 16, and W027 at the mouth of the Multnomah Channel). At each transect the river was divided into equal discharge increments (EDIs) using existing bathymetry and river flow data.

Six vertically integrated water column samples were collected using both peristaltic pumps and high-volume sample methods at two transect locations (W025 at RM 2 and W023 at RM 11). Each transect was subdivided into three lateral segments across the river as follows: east shoreline to navigational channel, navigational channel, and navigational channel to west shoreline. At the midpoint of each segment, a vertically integrated water column sample was collected. Details on this transect sampling approach are provided in Appendix G of the Round 3A Surface Water FSP (Integral 2006k).

Single-point NB/NS peristaltic and high-volume samples were collected at 12 locations (W026 at RM 2, W028 at RM 3–4, W029 at RM 4–5, W030 at RM 5–6, W031 at RM 6–7, W032 at RM 6–7, W033 at RM 7, W034 at RM 7–8, W035 at RM 8–9, W036 at RM 8–9, W037 at RM 9–10, and W038 at RM 9–10). High-volume XAD samples were collected only for PCB congeners at eight locations (W026, W028, W029, W030, W034, W036, W037, and W038).

River stage and river flows on the Willamette River at Portland, as well as local precipitation levels that occurred during the surface water sampling period (November 2–5, 2006), are shown in the FSR (Integral 2007b).

Winter 2007 High-flow Event

This event was conducted during a high-flow event (Q>50,000 cfs) by collecting NB/NS peristaltic samples and XAD samples at 16 Round 3A locations (Map 2.1-18). In addition, three vertically integrated peristaltic and XAD samples spaced laterally across the river at two Round 3A transect locations (W023 at RM 11 and W025 at RM 2) were collected during high-flow conditions.

The high-flow surface water sampling event was split into two phases because of a sudden drop in precipitation after the first 3 days of sampling. The first phase took place January 15–18, 2007. On January 18, 2007, the high-flow surface water collection program was cancelled due to the flow of the Willamette River dipping below 50,000 cfs. The second phase resumed on February 21 through March 10, 2007.

Cross-sectional NB/NS peristaltic and high-volume samples were collected at four Round 3A transect locations (W005 at RM 4, W011 at RM 6.3, W027 at the mouth of the Multnomah Channel, and W024 at RM 16). At each transect the river was divided into EDIs using existing bathymetry and river flow data (Integral 2006n, Appendix A). During the first phase of the high-flow sampling event, sampling at transect W024 started on January 15, it was then interrupted by a snow storm on January 16, and resumed from January 17–18, 2007. This station was not resampled with the remaining sampling stations during the second phase. All other cross-sectional NB/NS transects were sampled from February 21 through March 10, 2007.

Eight vertically integrated water column samples were collected using both peristaltic pumps and high-volume sample methods at two transect locations (W025 at RM 2 and W023 at RM 11). Each transect was subdivided into three lateral segments across the river as follows: 1) east shoreline to navigational channel, 2) navigational channel, and 3) navigational channel to west shoreline. At the midpoint of each segment, a vertically integrated water column sample was collected. Details on this transect sampling approach are provided in Appendix G of the Round 3A Surface Water FSP (Integral 2006k). During the first phase, the sampling stations located in the middle of the navigational channel at W023 and W025 were sampled on January 15, 2007, and were sampled again during the second phase on March 2 and March 10, 2007, respectively.

During the second phase of the high-flow sampling event, single-point NB/NS peristaltic and high-volume samples were collected at 12 locations (W026 at RM 2, W028 at RM 3–4, W029 at RM 4–5, W030 at RM 5–6, W031 at RM 6–7, W032 at RM 6–7, W033 at RM 7, W034 at RM 7–8, W035 at RM 8–9, W036 at RM 8–9, W037 at RM 9–10, and W038 at RM 9–10). High-volume XAD samples were collected for PCB congeners only at eight locations (W026, W028, W029, W030, W034, W036, W037, and W038). All samples were collected from February 21 through March 10, 2007.

River stage and river flows on the Willamette River at Portland, as well as local precipitation levels that occurred during the surface water sampling period (January 15–

18, 2007 and February 22 through March 10, 2007), are shown in the FSR (Integral 2007c).

2.1.4.1.2 Groundwater – Gunderson Site

The Gunderson site is an industrial facility located between RM 8.5 and 9.2 on the west bank of the Willamette River. A volatile organic compound (VOC) groundwater plume is present in the upland groundwater of Area 1 at the Gunderson site, resulting from a historical spill of 1,1,1-trichloroethane (1,1,1-TCA). The primary objective of this effort was to gather information to allow evaluation of the stratigraphic trend of the deep conductive (gravel/sand) zone offshore of the Gunderson Area 1 site. The goal was to determine whether possible discharge areas could be identified where TZW sampling might be used to evaluate such discharges, and to focus that sampling, if needed.

Stratigraphic cores were collected offshore of the Gunderson Area 1 at nine locations between October 16 and October 19, 2007 (Map 2.1-22). Sampling was conducted in accordance with the Round 2 GWPA SAP (Integral, Kennedy/Jenks, and Windward 2005), Round 3 GWPA HSP Addendum II (Integral 2007o), and the Round 3 GWPA FSP (Integral 2007i). The nine stratigraphic core locations are shown on Map 2.1-22. Table 3-1 of the FSR (Integral 2007e) lists the stations, core lengths, and number of field flame ionization detector reading intervals. Complete field notes are presented in Appendix B of the FSR (Integral 2007e). Core log description forms for the nine stratigraphic cores are presented in Appendix C of the FSR and a comparison of target and actual core locations is presented in Appendix D of the FSR (Integral 2007e).

2.1.4.1.3 Stormwater

The objectives of the RI/FS stormwater sampling program were to evaluate stormwater contribution to in-river fish tissue chemical burdens and determine the potential for recontamination of sediment (after cleanup) from stormwater inputs. In summary, the planned sampling approach described by the FSP (Anchor and Integral 2007b,c) included the following:

- Flow-weighted composite storm water samples using automated Teledyne ISCO samplers from three storm events, including whole water for organic compound analyses and filtered/unfiltered pairs for metals analyses
- One additional set of grab stormwater samples at 10 of the 23 planned sampling locations for sampling of filtered/unfiltered pairs and analysis of selected organic compounds and associated conventional analytes
- Sediment trap deployment (to collect suspended sediment from stormwater and analyze for sediment chemistry) for a minimum duration of 3 months.

The LWG sampling activities are described in detail in the Round 3A Stormwater Sampling FSP (Anchor and Integral 2007b), Round 3A Stormwater Sampling FSP Addendum (Anchor and Integral 2007c); and the Round 2 QAPP Addendum 8 (Integral

2007m). The FSP, FSP Addendum, and QAPP are companion documents to the Round 3A Stormwater Sampling Rationale (Anchor and Integral 2007d), which describes the reasoning behind the overall sampling approach.

The first round of stormwater sampling, Round 3A, was conducted from February through July 2007 and included collection of composite stormwater samples, grab stormwater samples, and sediment trap stormwater samples. During Round 3A, flow-weighted stormwater samples were collected at 33 locations (including LWG, Terminal 4, and GE Decommissioning Facility sites), grab samples were collected at 10 LWG locations, and sediment samples were collected from 24 LWG locations plus 6 additional locations in the vicinity of Terminal 4 (Map 2.1-23). The Round 3A sampling resulted in less than the total number of desired samples, as described in the Round 3A FSP (Anchor and Integral 2007b) so a second round of sampling was planned to commence in the fall of 2007.

The second round of sampling, Round 3B, was conducted from November 2007 through February 2008. Round 3B consisted of collection of flow-weighted stormwater samples by an ISCO sampling device from 17 locations (including LWG, Terminal 4, and GE Decommissioning Facility sites) and sediment trap samples from 12 LWG locations plus six additional locations in the vicinity of Terminal 4 (Map 2.1-23). A detailed description of field efforts associated with the Round 3A and 3B Stormwater Sampling Field Data Report is included in the respective FSRs (Anchor and Integral 2007a; Anchor and Integral 2008d; Ash Creek Associates/Newfields 2008).

Rainfall data for Round 3A and 3B stormwater sampling were obtained from five established rain gages in the City of Portland Hydra Rainfall Network. These rain gages included Albina, Swan Island, Terminal 4, WPCL, and Yeon. The rainfall data obtained from each gage were used to make sampling decisions throughout the course of the sampling and to understand the flow results for data reporting. Complete rainfall data for the duration of the project and the locations of the gages relative to stormwater sampling locations are included in Appendix C of the Data Report (Anchor and Integral 2008a).

In order to prevent sampling water from the Willamette River, stormwater sampling stations were specifically chosen to be at locations/elevations unlikely to experience a backup of river water into the junction or adjoining pipes. During the Round 3A and 3B sampling events, the gage height during the sampling periods was reviewed to verify that the sampling locations were not inundated by river water. The gage height of the Willamette River at the Morrison Street Bridge, USGS Station 14211720, was obtained from the USGS on a half-hour basis for the duration of the stormwater sampling. The records of gage height elevations for the duration of the sampling periods are included in Appendix D of the Data Report (Anchor and Integral 2008a).

2.1.4.1.4 Lamprey Ammocoete Tissue

A total of 23 stations were sampled for lamprey ammocoetes (*Lampetra* sp.) between September 20 and October 16, 2006 (Map 2.1-11). These included 21 sampling stations within the Study Area between RM 2 and 11 and two locations upstream of the Study Area. Sampling procedures for the collection of ammocoetes followed those detailed in the FSP (Windward 2006b).

The specific objectives of the Portland Harbor Round 3 lamprey ammocoete tissue sampling effort were as follows:

- Obtain site-specific empirical lamprey ammocoete whole body tissue data
- Measure concentrations of chemicals in lamprey ammocoetes from the Study Area for use in evaluating risks from hazardous substances to out-migrating lamprey larvae
- Determine whether lamprey ammocoetes from the Study Area have elevated concentrations of site-related contaminants compared with upstream reference areas
- Collect incidental information on lamprey habitat preference based on catch success.

Representatives of the regulatory agencies and trustees were present throughout the sampling effort, to oversee field operations. Observers were Jennifer Peterson from the Oregon DEQ, Joe Goulet and Eric Blischke from USEPA, Jeremy Buck and Mike Szumscki from the USFWS, Chris Thompson from Environmental International Ltd., Jeff Zakel on behalf of the Grand Ronde Tribe, and Stan Van de Wetering on behalf of the Siletz Tribe. Mike Fodale and Dan Kochanski from USFWS (Marquette Biological Station) were present September 20 through September 27, 2006, to provide sampling equipment training and troubleshooting.

The FSR (Windward 2006a) further discusses the field procedures and presents the number of casts conducted and estimated lamprey biomass collected at each sampling station. The FSR also provides figures showing the cast locations at the sampling stations.

2.1.4.1.5 Sturgeon Tissue

Five areas (i.e., reaches) of the river within the Study Area were sampled for pre-breeding white sturgeon (*Acipenser transmontanus*) between February 19 and March 6, 2007 (Map 2.1-10). The sampling and processing procedures followed those detailed in the FSP (Windward 2007c) and *Procedure for Sampling Fish, Collecting Tissues, and Conducting an External Fish Health Assessment* (USFWS 2007), also referred to as the SOP.

The specific objective of the Portland Harbor Round 3 pre-breeding white sturgeon tissue sampling effort was to obtain site-specific pre-breeding white sturgeon whole-body tissue samples for use in determining whether COIs in field-collected white sturgeon tissue from the Portland Harbor Site potentially pose unacceptable ecological risks to the sturgeon themselves.

Representatives of the regulatory agencies and trustees were present throughout the sampling effort to oversee field operations. Observers were Eric Blischke, Joe Goulet, and Dan Terpening from USEPA; Jeremy Buck, Ken Lujan, and Mike Szumski from USFWS; Ruth Farr from ODFW; Rob Neeley from NOAA; Jennifer Peterson from the Oregon DEQ; Sherrie Duncan from Ridolfi Inc.; Chris Thompson and Brent Finley from Environment International Ltd.; and Erin Madden on behalf of the Nez Perce Tribe.

A total of 403 white sturgeon were collected with set lines and by angling. Of this number, 384 were smaller than the legal size and subsequently released at the site of capture. Of the 19 legal-sized (42- to 60-inch) sturgeon collected, 1 was released accidentally, and 3 were released because the target quota for the reach in which they were caught had been met. A total of 15 legal-sized white sturgeon were retained for chemical analysis. In addition, one sub-legal-sized sturgeon was retained as a practice health assessment and dissection specimen.

Although it was not originally planned in the FSP, USEPA approved additional efforts to collect more sturgeon by supplementing the set lines with an angling effort. Twenty-two additional sturgeon were caught by angling on February 20 and 21, and March 5 and 6, 2007. However, no legal-sized (42- to 60-inch) sturgeon were captured during angling, and all sub-legal-sized sturgeon were subsequently released.

2.1.4.1.6 Fish and Invertebrate Tissue with Collocated Surface Sediment

The Round 3B fish and invertebrate tissue and collocated surface sediment field sampling activities were conducted between RM 1 and 12.2 from August 7 through December 6, 2007. The sample collection and processing methods used during the Round 3B field sampling effort followed the Round 3B Fish and Invertebrate Tissue and Collocated Surface Sediment FSP (Integral 2007k). The methods build upon previous experience collecting biota at the Site as described in the Round 1 FSP (SEA, Windward, Anchor, and Kennedy/Jenks 2002b), the Round 1 Laboratory QAPP (SEA 2002d), the Round 2 Benthic Invertebrate FSP (Windward and Integral 2005b) and Technical Memorandum (Windward and Integral 2005a), the Round 2 QAPP (Integral and Windward 2004) and QAPP Addenda 5 and 9 (Integral 2005q, 2007n), and the project HSPs (SEA 2002f; Integral 2004d, 2007p; Windward 2007f). All sampling and analysis methods detailed in this FSR were consistent with the methods used in previous FSPs and QAPPs for fish and invertebrate tissue and collocated sediment.

A reconnaissance survey was conducted by USEPA and LWG on August 7, 2007, to verify target sample locations and identify appropriate habitat for target species. Approval to proceed with the sampling was provided by USEPA in a letter dated

August 17, 2007 (USEPA 2007). Sampling locations shown in Maps 2.1-5, 2.1-8, and 2.1-9 reflect the sampling locations resulting from the field reconnaissance survey.

The Round 3B fish and invertebrate tissue and collocated surface sediment sampling event commenced on August 27, 2007 and was completed by December 6, 2007. The sampling dates for the various sample collection efforts are summarized below:

- August 27–September 28, 2007—Collection of all target fish and crayfish species.
- October 4–5, 2007—Acquisition of GPS coordinates for actual sculpin and crayfish sampling stations.
- October 15–18, 2007—Collection of collocated sediment samples at sculpin and crayfish stations.
- November 12–16, 2007—Collection of clam tissue.
- November 19–22, 2007—Collection of collocated sediment samples at clam stations, with an additional day of sampling on December 6, 2007.

Three fish species (sculpin, smallmouth bass, and carp), one crayfish species, and one clam species were collected for tissue analyses. In addition, collocated surface sediment was collected at crayfish, sculpin, and clam stations. Four sampling techniques were used during Round 3B to collect fish: backpack electrofishing, set lines (i.e., trot lines), angling, and crayfish traps. Clams were collected using a benthic sledge.

A total of 414 fish, 816 invertebrates, and 20 collocated sediment samples were collected over 32 field sampling days. Table F-1 in Appendix F of the FSR (Integral and Windward 2008) provides the records for each fish and invertebrate caught during the Round 3B sampling effort. The species collection effort included 230 sculpin, 80 crayfish, 136 smallmouth bass, 48 carp, and 736 clams. Twenty collocated sediment composites were collected at sculpin, crayfish, and clam sampling locations (Maps 2.1-5, 2.1-7, and 2.1-9).

Fishing and tissue collection efforts required a substantial amount of resources and personnel. Integral staff coordinated the overall effort, which was carried out primarily by personnel from Ellis Ecological Services as the fishing permit holder. Ellis Ecological Services was assisted by Windward Environmental LLC, SWCA Environmental Consultants, Kennedy/Jenks Consultants, Marine Endeavors LLC, Marine Sampling Systems, Mullins Guide Services, Benthic LLC, and the Oregon Bass Panfish Club.

All people directly involved with the fishing effort were authorized to collect fish under the NOAA Fisheries 4(d) scientific taking permit (OR2007-4082 partial and OR2007-4082M1 partial) and Section 10 scientific taking permit granted to EES by the ODFW.

Members of the regulatory agencies and trustees were present at various times to observe and oversee all aspects of field and field laboratory operations for fish, invertebrate, and collocated sediment collection and sample processing.

2.1.4.1.7 Sediment (Willamette Cove)

The objective of the Willamette Cove sediment sampling program was to locate the NAPL-impacted sediments reported by Oregon DEQ (2007) during an August 28, 2007 site walk and collect a representative surface sediment sample in accordance with the Round 2A surface sediment sampling protocol (Integral, Anchor, and Windward 2004) for the chemical analyses outlined in the data report (Integral 2008c). Except where noted in the data report (Integral 2008d), all surface sediment field activities, including sample collection, sample handling and processing, and data management, followed guidelines specified in the Round 2 QAPP (Integral and Windward 2004), the Round 2 QAPP Addendum 9 (Integral 2007p) and the Round 2 HSP (Integral 2004d).

On September 21, 2007, three test pits were excavated to locate NAPL-impacted sediments. A representative sample from the composited surface (0–30 cm) sediment was collected from one location for chemical analyses. The surface sediment sample LW3-GWC1 was collected according to the standard LWG field sampling protocol as outlined in the Round 2A FSP (Integral, Anchor, and Windward 2004). The location of the Willamette Cove sediment sample is shown in Map 2.1-15; coordinates and field logs are presented in Appendix B of the data report (Integral 2008d).

2.1.4.1.8 Sediment and Sediment Toxicity Bioassay Testing

The RI/FS objectives that the Round 3B sediment sampling efforts supported included the following:

- Collect synoptic sediment chemistry and toxicity data to fill data gaps required to complete characterization of risks to the benthic community
- Collect surface sediment chemistry data from the Upriver Reach of the lower Willamette River to support the determination of final background sediment concentrations
- Collect surface sediment chemistry data from Multnomah Channel to evaluate the potential for contaminant migration from the Study Area to Multnomah Channel
- Refine the lateral and vertical extent of sediment contamination by filling data gaps within the Study Area to complete the RI and to support the FS
- Collect subsurface sediment chemistry data within the Study Area to complete characterization of subsurface sediment in areas where subsurface sediments posing potentially unacceptable risk may be exposed by future extreme high-flow flood events.

Surface and subsurface sediment samples were collected during Round 3B from November 13 to January 17, 2008, in three separate reaches: 1) within the Willamette River from RM 2 to 12.2; 2) the upper reach of the Multnomah Channel; and 3) within the Willamette River from RM 15.3 to 26. Surface sediment grabs were collected at 188 stations and subsurface cores were collected at 88 stations within these reaches. All locations sampled during Round 3B are shown on Maps 2.1-15 and 2.1-17.

Surface sediment samples were collected from the 188 stations during Round 3B, including field replicates and split samples, resulting in 204 surface sediment samples submitted for chemical analyses, and 60 sediment samples collected for bioassay testing. A total of 94 subsurface sediment cores, which includes field replicates, were collected from 88 stations during Round 3B. Including the field replicates and homogenate split samples, a total of 244 subsurface sediment samples were submitted for chemical and/or physical analyses. Including 6 field replicates, 56 cores were collected from the Study Area and Multnomah Channel for chemistry analyses, 23 cores were collected in the Study Area for erosion study analyses, 5 cores were collected in the Study Area for both chemistry and erosion study analyses, and 10 cores were collected in the Study Area for geotechnical analyses.

Round 3B sample collection and processing procedures followed guidelines specified in the Round 3B Sediment FSP (Integral, Windward, and Anchor 2007a,b), the Round 2 QAPP (Integral and Windward 2004), and QAPP Addendum 10 (Integral and Windward 2007b). Deviations from the FSP and QAPP are discussed in the sediment and bioassay FSR (Integral 2008f) and summarized in the data report (Integral 2008e).

2.1.4.1.9 Sediment Traps

The suspended sediment component of the sampling program involved using sediment traps to collect the sediment settling from the surface water column. The primary purpose of Round 3 sediment trap sampling was to gather data for the evaluation of FS alternatives. In addition, this sediment trap work contributed to filling data gaps related to the nature and extent of potential sources and supported the preparation of the BERA.

The specific objectives of the Round 3 sediment trap sampling program were to collect sediment trap mass and chemical concentration data to further characterize the nature and extent of waterborne sediment contamination that enters the Study Area from upstream sources, is associated with regional sources within the Study Area, and exits the downstream end of the Study Area. The data will support the FS in terms of providing better understanding of potential inputs from regional sources, potential contributions from within and outside the Study Area, and the potential for recontamination and/or natural recovery of bedded sediments within the context of FS alternatives. The sediment trap sampling program was not designed to support estimation of chemical mass loading within or throughout the system.

Sediment traps were established in 16 locations in the lower Willamette River for Round 3 suspended sediment collection. To investigate the settling sediment load, pairs of sediment traps were deployed and maintained on both sides of the river approximately at RM 2, RM 6, just upstream of RM 11, and approximately at RM 16. Individual sediment traps were deployed and maintained at seven other locations throughout the Study Area and at one location in Multnomah Channel. The number and locations of sediment traps and the frequency of recovery and redeployment were designed to capture anticipated spatial and temporal variability of suspended sediment mass and to investigate the potential accumulation of suspended sediment chemical constituents in suspected depositional areas. The target and actual station locations are shown in Map 2.1-24.

The traps were deployed between October 30, 2006 and November 2, 2006, and were recovered quarterly for approximately 1 year. During the quarterly recovery, the accumulated sediments were collected for analysis in accordance with the FSP (Anchor 2006b), the Round 2 QAPP (Integral and Windward 2004) and Round 2 QAPP Addendum for Surface Water Sampling (Integral 2004e). The HSP (Integral 2004d) prepared and approved for the Round 2 sampling program was used as guidance for all aspects of Round 3 sediment trap sampling.

Samples were analyzed for conventional parameters (grain size, total solids, TOC, and specific gravity), metals, SVOCs, VOCs, total petroleum hydrocarbons (TPH), pesticides, PCB Aroclors, polychlorinated dibenzo-p-dioxin/furans (PCDD/Fs), and PCB congeners.

During the third quarter sampling, there was insufficient volume collected for the full analysis of five samples (ST3005, ST3006, ST3009, ST3011, and ST3013). Also, during the fourth quarter sampling, the volume of sediment collected from three locations (ST003, ST006, and ST009) was insufficient to conduct analysis of all COIs. Therefore, an analyte prioritization list for these samples was generated. This new prioritization scheme was approved by USEPA. The data analysis and prioritization scheme is discussed further in the data report (Anchor and Integral 2008a)

2.1.4.1.10 Upstream/Downstream Surface and Subsurface Sediment Samples

Surface and subsurface sediment samples were collected during Round 3A from January 30 to February 8, 2007, in two separate locations within the lower Willamette River: upstream reach from RM 9.5 to 12, and downstream reach from RM 0.9 to 1.9 (Maps 2.1-15 and 2.1-17). Samples were collected from 30 locations within these two reaches. A total of 30 surface sediment samples and 24 subsurface cores were collected from 30 stations during the Round 3A sediment sampling field event conducted from January 30 to February 8, 2007. Including field replicates and homogenate split samples, a total of 136 sediment samples were submitted for chemical and/or physical analyses, and 111 samples were submitted for radioisotope analyses.

The primary objectives of the upstream and downstream sampling program were as follows:

- Estimate contaminant loading to the Study Area from upstream during both typical hydrologic conditions and high-flow events
- Develop estimates of naturally occurring background concentrations and anthropogenic concentrations (consistent with USEPA policy) in surface water and sediment in the lower Willamette River upstream of the Study Area
- Assess the extent of potential downstream contamination from the Study Area in the lower Willamette River below RM 2 and in the upstream portion of Multnomah Channel.

The Round 3A upstream sediment program consisted of surface (0–30 cm) and subsurface sediment sampling and analysis in the reach from approximately RM 9.5 to 12. One set of cores was collected in known long-term depositional areas and analyzed for both radioisotope and contaminant chemistry to support the characterization of contaminant loading to the upper Study Area from upstream over time. Another set of cores was collected at two areas USEPA identified as potential upstream sources of contamination and processed for contaminant chemistry only.

The Round 3A downstream program consisted of surface (0–30 cm) and subsurface sediment sampling and analyses in the Willamette River from approximately RM 0.9 to 1.9 and a precision multibeam bathymetric survey in the Multnomah Channel from the Willamette River to the Sauvie Island Bridge.

The Round 3A upstream and downstream sediment samples were processed using protocols established in Round 2A and 2B. Except where noted, all Round 3A surface and subsurface sediment field activities, including vessel positioning, sample collection, sample handling and processing, and data management, followed guidelines specified in the Round 3A FSP for Upstream and Downstream Sediment Sampling (Integral 2006q), the Round 2 QAPP (Integral and Windward 2004), and the Round 2 HSP (Integral 2004d).

Round 3A sediment samples were analyzed according to methods described in the Round 2 QAPP (Integral and Windward 2004), with modifications described in the Portland Harbor RI/FS Round 2 QAPP Corrective Action Plan: SVOC Analysis of Sediment Core Samples (Integral 2004g), and Portland Harbor RI/FS Round 2A SCSR (Integral 2005s). Laboratory deviations were reported in the Round 3A Upstream & Downstream Sediment Data Report (Integral 2007g).

2.1.4.1.11 Natural Attenuation (Radioisotope Subsurface Sediment Cores)

During the January 30 to February 8, 2007 upstream and downstream sediment sampling event, subsurface sediment was collected for radioisotope analyses at three locations (RC01, RC02, and RC483) in the upper Study Area. The radioisotope chemistry core locations are shown in Map 2.1-19. Core logs for the radioisotope cores are provided in Appendix C of the Upstream and Downstream Data Report (Integral 2007g). A total of 111 samples (35 samples from core RC01, 38 samples from core

RC02, and 38 samples from core RC483) were submitted for 7Be, 226Ra, 137Cs, and 210Pb radioisotope analyses.

The radioisotope cores were subsectioned into 2-cm intervals throughout the entire depth of each core, with a subset of these segments submitted for radioisotope analysis per the Round 3A FSP (Integral 2006q). Deviations from the analytical methods specified in the FSP, project QAPP, and laboratory QAPP (Appendix E; Integral 2006n) for radioisotope analysis are summarized in Section 3.4 of the data report (Integral 2007d).

2.1.4.1.12 Sediment Chemical Mobility Testing

Sediment chemical mobility testing activities were conducted from August 18 through September 5, 2008. Sediment cores were collected at 55 locations from August 18 to August 29, 2008, within RM 2 to 11 (Maps 2.1-17b-o). Surface water was collected from September 2 to September 5, 2008, within 11 initial areas of potential concern (AOPCs).

The sediment chemical mobility testing sediment and surface water field sampling activities were intended to support the FS by evaluating the chemical mobility of contaminated sediment that may potentially be remediated. Sediment chemical mobility testing sampling efforts included sediment, surface water, elutriate, and leachate chemistry focused within RM 2 to 11 of the lower Willamette River. The sampling effort included collection of sediments that will be subjected to three types of elutriate or leachate production protocols: modified elutriate test, sequential batch leachate test, and toxicity characteristic leaching procedure tests. The modified elutriate and sequential batch leachate tests are described in the Corps Upland Testing Manual (USACE 2003) and the toxicity characteristic leaching procedure is described in federal regulations (40 CFR §261.24). These three test protocols are intended to provide information for the FS about leachate or elutriate production and chemical concentrations during various stages of sediment removal and disposal. The sequential batch leachate test can also be used to understand potential chemical mobility for some capping scenarios. To support these tests, analysis of subsurface bulk sediment chemistry and surface water chemistry were conducted to understand the chemical levels present in the materials used in the tests.

Sample collection and processing procedures followed guidelines specified in the Sediment Chemical Mobility Testing FSP (Anchor 2008b), the Round 2 FSP (Integral, Anchor, and Windward 2004), the Round 2A Surface Water FSP (Integral 2004b), the Round 2 QAPP (Integral and Windward 2004), QAPP Addendum 10 (Integral and Windward 2007b), the Sediment Chemical Mobility Testing QAPP Addendum 11 (Integral 2008g), and the project HSPs (Integral 2004d, 2007q). Deviations from the FSP and QAPP are discussed in the FSR and data report (Anchor and Integral 2008d; Integral 2009).

2.1.4.1.13 Side-scan Sonar

The side-scan sonar survey was conducted in accordance with the Round 3B Side-scan Sonar FSP (Anchor 2008c). The survey was timed to occur during the spring freshet, when the water level in the river is highest, to maximize bank-to-bank side-scan sonar coverage. The survey was performed from May 30 through June 4, 2008. The side-scan sonar survey area extended from RM 1, at approximately the small slough that enters the Willamette River immediately downstream from the Columbia Grain Terminal, to RM 12.2, at approximately 1,100 ft upstream of the Steel Bridge. The survey area included an approximately 2,500-ft-long segment of the Multnomah Channel and full coverage of the ship basins at the Schnitzer Terminal and Portland Shipyard. The survey did not include Slips 1 and 3 of Terminal 4 at the Port of Portland.

The first objective for the side-scan sonar survey was to determine the approximate distribution of pilings, dolphins, submerged structures and debris in the river channel and along both banks of the river to support decision-making processes related to the FS. An initial round of sonar data processing identified 1,369 targets. The side-scan sonar survey identified a total of 7,445 discrete targets in the approximately 12.2 miles of the lower Willamette River surveyed. The vast majority of targets identified are pilings and dolphins associated with docks and pier faces. Other targets include logs, miscellaneous debris, and surficial features including depressions, gravel, and anchor drag scours. It is likely that additional features and targets are present in the river below layers of silt or sand that would not be identified by the side-scan sonar survey.

Approximately two-thirds of the targets identified were clearly man-made objects (piers, pilings, dolphins, and structures) emplaced in the river for navigational, operational, or engineering purposes. Approximately 25 percent of the remaining material was classified as either debris, debris-NMH (no measurable height), or unclassified (debris). Debris was commonly found along the margins of dock structures and approximately a boat width away from them, a pattern that is consistent with vessel activity patterns.

The second objective of the side-scan sonar survey was to produce a mosaic of the side-scan sonar imagery to map the occurrence of surface sediment types (i.e., sands, fines, etc.) as they occur throughout the survey area. The interpreted sonar images are presented in the Side-scan Sonar data report (Anchor QEA 2009a). The interpretations were based on sonar backscatter intensity and sediment morphology. Interpretation of the side-scan sonar data by the survey analyst suggests that the bulk of the river is medium-grained sand. Areas of increased sonar backscatter were interpreted as coarse-grained sand. Areas of reduced sonar backscatter were interpreted as fine-grained sand and silt. Sand waves are noted in the channel center in the upper reaches of the survey area and are most notable in areas that have not been extensively dredged. It was not the intent of this survey to compare sediment morphology on the sonar image to any previously collected sediment grain size data.

2.1.5 Other Investigation Summaries

Nearly 700 documents have been compiled into the Portland Harbor RI/FS project library. These documents include analytical data, ecological studies, facility investigations, regional studies, and other non-specific documents about the Portland Harbor area. Specific historical and recent studies and data sets were selected for inclusion in this RI report, based on their representativeness of current site conditions. Information obtained from these other sources includes the following:

- Regional setting information from geologic maps, government and scientific literature regarding structural geology and hydrogeology, information on regional datums and meteorology, and historical and recent bathymetric studies conducted by NOAA
- Regional development and current human use area information from aerial photographs, zoning and fire insurance maps, City of Portland Bureau of Planning documents, and the City of Portland Willamette River Atlas
- Extensive information on lower Willamette River upland site characteristics and contaminant pathways that guided RI sampling programs and supported CSM development—including historical development and land uses, industrial operations, and COIs—provided by Oregon DEQ's Environmental Cleanup Site Information (ECSI) database, individual upland site investigation reports, and government publications
- Extensive information on non-municipal and municipal outfalls and upland drainage systems that contributed to the CSM, provided by the City of Portland, Oregon DEQ's Joint Source Control Investigations, the Columbia Regional Association of Governments (CRAG) studies, and individual upland site reports
- Dredging and capping histories from individual site reports and USACE permits
- Site habitat information and riverbank type designations supporting the BHHRA and BERA, provided by ODFW documents, the City of Portland Natural Resources Inventory Update (City of Portland 2008a), and the scientific literature
- Site fish and wildlife resident populations, behavior, and consumption information that support the BHHRA and BERA (e.g., Agency for Toxic Substances and Disease Registry [ATSDR] documents; Columbia River Inter-Tribal Fish Commission [CRITFC] documents; Oregon Department of Health Services [ODHS] et al. 2003)
- Upland discharge information supporting fate and transport loading estimates, provided by government planning documents, Oregon DEQ, and National Pollutant Discharge Elimination System (NPDES) discharge permit information
- Willamette River stage and flow data from the USGS Morrison Bridge station (#14211720) used to support fieldwork planning and calculate CSM loading estimates

- Chemical use and toxicity information to support the BHHRA, BERA, and CSM from government documents (e.g., ATSDR toxicological profiles, etc.) and the scientific literature (e.g., Batt 2004; Friberg et al. 1986)
- Studies on contaminant hazards posed to fish and wildlife (e.g., Eisler 1986, 1987, 1988, 1993, 1998)
- Contaminant fate and transport process information provided by other site investigations (e.g., Steuer 1995) and the scientific literature (e.g., Erickson 1997).

The above list and examples given are not meant to be inclusive of all the information sources utilized in this RI. A complete list of these investigations is summarized in Table 2.0-2 and presented in Maps 2.1-15 and 2.1-17. Appendix A1 provides additional information on the data collected by other parties.

2.2 DATA QUALITY ASSESSMENT

The data quality assessment process is a comparison of the implemented sampling approach and resulting analytical data against the sampling and data quality requirements specified by the data quality objectives. Results of the data quality assessment are used to determine whether data are of adequate quality and quantity to support the decision-making process. The data quality assessment performed for this study includes evaluation of the quality of the analytical data generated for each of the field sampling efforts and evaluation of the adequacy of the data set in meeting the intended data uses.

2.2.1 Data Quality Objectives

The data quality objectives process is a strategic planning approach based on the scientific method to prepare for a data collection activity (USEPA 2000a). It provides a systematic procedure for defining the criteria that a data collection design should satisfy. This includes when to collect samples, where to collect samples, the tolerable level of decision error for the study, and how many samples to collect, balancing risk and cost in an acceptable manner.

A significant amount of historical information, both quantitative and qualitative, exists for the Study Area. The data quality objectives process was used early in the RI/FS process to identify specific data needs relative to the design of RI/FS field investigations and development of potential remedies. Data needs that ensued from the data quality objectives process formed the basis of the RI/FS sampling program. Table 2.2-1 presents an overview of data collection activities needed to fill data gaps for the preliminary remedial action objectives and RI/FS site characterization objectives. These data gaps were used to develop the FSPs for the Portland Harbor Study Area. Since data collection is an iterative process, additional data gaps were identified throughout the data collection process and used to develop additional FSPs.

2.2.2 Laboratory Data Quality/Data Validation

To provide a high level of quality for the analytical data collected during this study, samples were submitted to commercial laboratories for analysis in accordance with USEPA-approved QAPPs.

USEPA has not established definitive guidelines specifying the level of data validation required for Superfund investigations. However, USEPA Order 5360.1 and Office of Solid Waste and Emergency Response Directive 9355.9-01 (USEPA 1993a) requires that environmental measurements be of known quality, verifiable, and defensible. The Office of the Inspector General concluded in an audit of Region 9 Superfund sites (USEPA 1995) that data used for cleanup decision-making should be validated using USEPA functional guidelines (USEPA 1999, 2002a). According to these guidelines, two different levels of data validation are generally recognized for chemistry data. A summary data validation, referred to as QA1, represents a lower level of effort compared with a full validation, referred to as QA2. The elements of summary and full data validations for environmental chemistry data are presented in Table 2.3-1 (USEPA 1999, 2002a).

All RI data were validated by Integral Consulting Inc.'s (Integral) senior chemists and spot checked by a USEPA Quality Assurance Specialist. Following data validation, the data set was further reviewed for proper application of data qualifiers. Data identified during validation as being unacceptable for project uses were not carried forward in the RI.

Data of acceptable quality may still be associated with uncertainty in the RI. For example, a chemical not detected in a sample may actually be present, but its concentration below the reporting limit is unknown. This uncertainty applies to all cases in which chemicals are reported as not detected; the magnitude of this uncertainty increases with increasing reporting limits. None of the sampling events evaluated for inclusion in the RI were excluded in their entirety because of elevated reporting limits. The uncertainties associated with data quality and that are relevant to conclusions of the risk assessments are discussed in both the BHHRA (Appendix F) and the BERA (Appendix G).

Methods for performing data quality reviews for data generated by the LWG are described in the project-specific QAPP. In addition, a detailed review of the quality of each non-LWG chemical and biological data set was performed prior to entering those data sets into the project database. Methods for reviewing non-LWG data are described in the Programmatic Work Plan (Section 4 and Appendix F; see Integral, Windward, Kennedy/Jenks, Anchor, and GSI 2004).

Two overall data quality categories were established in the Programmatic Work Plan, as follows:

- **Category 1.** Category 1 data are of known quality and are considered acceptable for use in decision making for the Site. There is sufficient information on these data sets to confidently verify that the data, along with associated data qualifiers, accurately represent chemical concentrations present at the time of sampling.
- **Category 2.** Category 2 data are of generally unknown or suspect quality. The quality assurance and quality control (QA/QC) information shows that data quality is poor or suspect, or essential QA/QC data (e.g., surrogate recoveries, matrix spike/matrix spike duplicates) are either incomplete or lacking.

The evaluation of data quality was conducted at the finest level of detail available for each data set. This evaluation focused on individual analyte groups within each survey when possible, and so any given survey may contain all Category 1 data, all Category 2 data, or a combination of Category 1 and 2 data. In addition, data that received a QA1 or QA2 level of validation were flagged as such, providing a combined data quality category (e.g., Category 1 QA2). For chemistry data, Category 1 and 2 designations were entered into the project database for each sample and analyte. Sample counts of Category 1 and Category 2 data are summarized in Table 2.3-2.

Criteria for placing data sets into categories were developed during the compilation of existing information to identify basic data qualities and not to limit data to specific program uses. Project decisions will be based on analyses using Category 1 data. Category 1 data that have had a USEPA-approved level of data validation, comparable to Washington State Department of Ecology's "QA2" evaluation, are designated as "Category 1 QA2" data sets. All data generated by the LWG hold the Category 1 QA2 designation. Some data generated by other parties are also designated Category 1 QA2. Non-LWG Category 1 data that received an abbreviated level of review are termed "Category 1 QA1." Only Category 1, QA2 data are used in the BHHRA, the BERA, and the determination of background chemical concentrations (Section 7). Both Category 1, QA1 and QA2 data are used to describe the in-river distribution of contamination (Section 5) and to evaluate contaminant loading, fate, and transport (Section 6). Category 2 data were generally used for project scoping. For example, Category 2 tissue data were used to help identify COIs, and Category 2 sediment data were used in the initial assessment of trends in contaminant concentrations, which was useful for developing sampling programs. No Category 2 data for environmental media other than sediment are included in the RI data set provided in Appendix A3.

2.2.2.1 Chemical Data Review Criteria

Chemical data quality was assessed by evaluating the following factors:

- Traceability
- Comparability
- Sample integrity

- Potential measurement bias
- Accuracy
- Precision.

All of these factors were known or supported by existing QA/QC information (analytical methods, chain-of-custody, sample holding time, method blanks, matrix spike/matrix spike duplicates, laboratory control samples, replicates, surrogates) for Category 1 data. If supporting documentation for each factor was not available or was not reinforced by the availability of other high-quality QA/QC information, data were assigned a Category 2 designation. If the acceptance criteria for any of the above factors were not satisfied for either the entire data set or a specific analyte group, data for that data set or group were generally qualified and were determined to have limited usefulness. The chemical data were reviewed by analyte group (e.g., metals, SVOCs). As a result, a data set may contain all Category 1 data, all Category 2 data, or both Category 1 and Category 2.

2.2.2.2 Biological Data Review Criteria

Bioassay data quality was evaluated based on validation guidelines and performance criteria from the Puget Sound Estuary Program (PTI 1989). Bioassay validation guidelines include checks of completeness, holding conditions, standard reporting methods, and QA/QC results for negative control, reference sediment, positive control (reference toxicant), and measured water quality parameters according to standard testing methods and established performance criteria.

2.2.2.3 Sediment Stability and Temporal Integrity

The RI data set only includes data that were collected after the winter of 1996/1997 and that meet the other usability criteria described above; the earliest data included in the database were collected in May 1997. The assumption is that while near-surface changes in chemical concentrations due to sediment scour or accretion certainly have occurred in places, no natural large-scale erosion events or re-exposure of buried deep sediments has occurred since that time.

2.2.3 Data Usability

The data usability evaluation is a comparison of the implemented sampling approach and resulting analytical data against the sampling and data quality requirements specified in each field sampling and analysis plan. The purpose of each data collection effort is to investigate impacted areas or areas potentially impacted to determine if observed contaminant concentrations are greater than applicable screening levels. If concentrations are less than screening levels, the area is considered not impacted. The purpose of the RI study is to evaluate available information and determine which areas, or media (e.g., soil, sediment, groundwater, surface water), are impacted by contaminant releases. For areas or media that are considered impacted, the information is carried through and evaluated further in the risk assessments and FS.

The sampling plans were designed to provide data to decide if areas are impacted within the Study Area. Since data can only estimate what the true condition of an area is, decisions that are based on measurement data could be in error. The data collected for this study were conducted judgmentally; therefore, the degree of certainty associated with these data sets cannot be evaluated.

The following sections describe the composition of the data sets for each RI data type. Additional information on the data set selection criteria for each data type in the RI, BHHRA, and BERA is provided in Appendix A3.

2.2.3.1 Sediment

Sediment chemistry data in the RI data set include LWG data collected from Rounds 1, 2, and 3 and data collected by other parties. The data documents are referenced in Tables 2.0-1 and 2.0-2. Only Category 1 QA2 surface sediment data that were not subsequently dredged or capped were used in the BHHRA and BERA.

The LWG data set is composed of samples collected from shorebird foraging beaches and human use beaches (surface transect composites), riverbed sediment samples (surface and subsurface), samples from biota sampling locations (collocated surface sediment), sediment toxicity samples (surface sediment), samples from TZW sampling locations (collocated surface sediment), and physical sediment characteristic samples (surface and subsurface). Data collected by other parties consist primarily of surface and subsurface riverbed samples. The majority of LWG surface and subsurface riverbed sediment samples were collected during Rounds 2 and 3 (some collocated surface sediment was collected in Round 1 from benthic invertebrate stations in the Study Area). Surface and subsurface sediment data were collected from the Study Area (RM 1.9–11.8), Multnomah Channel, downstream (RM 0–1.9), downtown Portland (RM 11.8–15.3), and upriver (RM 15.3–28.4). Surface and subsurface sediment sampling locations for all three LWG rounds, as well as studies conducted by other parties, are shown in Maps 2.1-15 and 2.1-17, respectively. LWG samples are identified by task/survey IDs “LWG01” (Round 1, surface samples only), “LWG02” (Round 2, surface and subsurface samples), and LWG03 (Round 3, surface and subsurface samples). Non-LWG sample survey IDs are cross-referenced to investigation summaries presented in Table 2.0-2 and Appendix A1. Numbers of samples and analyses performed on each sample are summarized in Table 2.3-3.

2.2.3.2 In-river Sediment Traps

The RI data set includes in-river sediment trap data collected by the LWG during Round 3. Data collected by the Port of Portland at Terminal 4 were excluded from the RI data set. Sediment trap data were not used in the BHHRA or BERA.

The LWG traps were deployed and maintained for 1 year at 12 locations within the Study Area, one location just downstream of the Study Area at RM 1.8, two upstream locations near RM 16, and at one location in Multnomah Channel (Map 2.1-24). The number of sediment traps and the frequency of recovery and redeployment were designed to capture anticipated spatial and temporal variability of suspended sediment mass and to investigate the potential contributions of chemicals via waterborne sediment for various regions of the Study Area. The LWG sediment trap sampling program was not designed to support estimation of chemical mass loading within or throughout the system. Table 2.3-4 lists the sample counts and analyses performed on each sample.

2.2.3.3 Bank Sediment and Soil

The RI data set includes bank (also referred to as the riparian zone; see USEPA 2005a) sediment and soil data largely collected by other parties as part of bank and upland investigations. Figure 2.2-1 depicts the shoreline boundary graphically. As discussed in Appendix A3, surface sediment/soil data of any quality collected below the mean high water line between +13 ft NAVD88 and +20ft NAVD88 are included in the RI data set. Bank sediment and soil data were not used in the BHHRA or BERA.

2.2.3.4 Surface Water

The RI data set includes data collected by both the LWG and other parties (Tables 2.0-1 and 2.0-2). The characterization of surface water in the following sections of the RI report includes the LWG-collected data, TSS data collected by the City of Portland, and TSS and TOC data collected by NW Natural at the Gasco site. In addition, naphthalene data from samples collected off the Siltronic Corporation facility are included in the RI data set. All other surface water data collected by other parties were excluded from the presentation of surface water data. Only LWG data were included in the BHHRA and BERA.

Surface water chemistry and conventional data in the RI data set include samples collected during three surface water sampling events that took place during Round 2A and four events during Round 3A. Sampling stations included both river-wide transects and single-point sampling stations at specific locations. River-wide transect sampling was designed to estimate integrated water concentration through a cross section of the river, or fraction of a cross section, at a point in time. Single-point samples were stationary samples or sample pairs located adjacent to amphibian habitats to support the BERA, in generally quiescent areas adjacent to beaches that are used by swimmers to support the BHHRA, and near known or suspected sources.

Round 2A data were collected at three transect stations (RM 4, 6.3, and 11) and at 20 single-point stations. Round 3A surface water samples were collected at six transect stations (RM 2, 2.9 [Multnomah Channel], 4, 6.3, 11, and 16) and 12 single-point stations. Offshore of Gasco (RM 6), single-point surface water samples were collected from 20 locations from three depths: near surface, mid-depth, and near-bottom for each of three tidal periods for a total of 180 samples. Near-bottom water samples were also collected at three locations at slack points in the tidal cycle, for a total of 12 samples (Anchor 2006c). At Siltronic, surface water was collected from 17 near-bottom locations collocated with groundwater sampling locations. Five surface water samples were also collected upstream and downstream of the site (MFA 2005a). Map 2.1-18 shows the surface water sampling locations, and Table 2.3-5 lists the sample counts and analyses performed on each sample.

2.2.3.5 Stormwater

The RI data set includes data and stormwater grab, sediment trap, and catch basin solids sample data collected by the LWG and other parties (Tables 2.0-1 and 2.0-2). Only the data collected by the LWG were used to generate estimated stormwater loads to the Study Area for the purposes of fate and transport modeling and recontamination analysis (see Section 6). Other stormwater data were provided by Oregon DEQ in early 2008 for sites collecting data under the JSCS program; these data are presented in Section 4.4, but were not used to develop stormwater loading calculations. Although stormwater permit data collected under the NPDES program was reviewed, no stormwater discharge permit data are included in the RI data set because chemical monitoring requirements for these permits are typically limited to a few chemicals that are hazardous substances. Of the non-LWG data, Category 1 data collected since June 1, 2004, are presented in Section 4 of the RI report for reference purposes only, but are not used in estimating stormwater loads. Stormwater data were not used in the BHHRA or BERA. Sampling locations for both the LWG and non-LWG data are shown on Map 2.1-23, and sample counts and analyses performed on each sample are summarized in Table 2.3-6.

2.2.3.6 Groundwater, Seeps, and Transition Zone Water

The transition zone is defined as the interval where both groundwater and surface water comprise some percentage of the water occupying pore space in the sediments (USEPA 2008a). The RI data set includes all TZW chemistry data collected by the LWG during Round 2, as well as groundwater, seep, and TZW data collected by other parties. TZW data were evaluated in the BHHRA and BERA. TZW data were collected by the LWG at nine sites located within the Study Area (Maps 2.1-20a-c), selected in agreement with USEPA as sites with a confirmed or reasonable likelihood for discharge of upland groundwater COIs to Portland Harbor. Additional stratigraphic characterization of a riverbed area offshore of the Gunderson site (RM 9) was conducted during Round 3, but it was determined that sampling of TZW at this site would not be necessary because the stratigraphic data did not provide physical evidence of a potentially complete flow pathway.

Seeps are defined as locations where water discharges from the ground either above or below the river surface (GSI 2003a). Seep data collected from Outfall 22B were also evaluated in the BHHRA.

Additional upland and baseline groundwater data collected by other parties were not included in the Portland Harbor RI data set, but were evaluated in Section 4 and are described in detail in Appendix C2.

Table 2.3-7 lists the numbers of samples and analyses performed on each sample.

2.2.3.7 Biota

The RI data set includes LWG-collected biota tissue data and adult Chinook salmon, adult lamprey, and adult sturgeon fish tissue data from the ODHS/USEPA/ ATSDR Fish Contaminant Study (ODHS et al. 2003). Biota tissue types included in the BHHRA or BERA are provided in Appendix F and Appendix G, respectively. No other data collected and evaluated by other parties were of acceptable quality for the BHHRA evaluation.

Fish and invertebrate tissue chemistry data were collected from the Study Area by the LWG and other parties to estimate exposure concentrations (as tissue residues or diet) for appropriate species or groups of ecological receptors (i.e., benthic invertebrates and fish). Biota tissue data were also collected upriver of the Study Area. Sampling locations for field-collected biota during all three sampling rounds are shown on Maps 2.1-5 through 2.1-11. Sampling locations specific to small-home-range species of fish and invertebrates are shown on Maps 2.1-5 and 2.1-6; large home-range fish species are shown on Maps 2.1-7 through 2.1-11. Table 2.3-8 summarizes the biota samples and analyses. Tables 2.3-9a-b list the LWG and non-LWG sample counts, respectively, and analyses performed on each sample. Table 2.3-10 provides the number of fish and invertebrates in each sample composite.

2.2.3.8 Bioassay

In Rounds 2 and 3, 293 surface sediment samples from the Study Area and upriver were submitted to a bioassay testing laboratory for toxicity testing. Two whole-sediment toxicity testing protocols were employed; the 10-day *Chironomus tentans* and the 28-day *Hyalella azteca* sediment toxicity tests measuring survival and growth. Bioassay reference stations were also collected upriver of the Study Area. Sediment bioassay sampling locations are shown on Map 2.1-5. These bioassay data are included in the BERA data set only (Appendix G).

Bioassays were also performed using commercially supplied clams (*Corbicula fluminea*) and laboratory-cultured worms (*Lumbriculus variegatus*) exposed to surface sediments collected at the same locations where field clams and worms were collected within the Study Area (Map 2.1-21). Results of the LWG’s laboratory bioaccumulation bioassays were also included in the RI data set.

2.2.3.9 Invertebrates

Invertebrate tissue in the RI data set includes LWG field-collected tissue samples for crayfish (*Pacifasticus leniusculus*), clam (*Corbicula fluminea*), mussels (tentatively identified as *Margaritifera falcata* and *Anodonta nuttalliana*), and epibenthic invertebrates and zooplankton collected with multiplate samplers. Invertebrate sampling locations for these small-home-range species are shown on Map 2.1-5. For clams, mussels, and crayfish, the map locations are shown as centroids of the specific sampling areas for each species (i.e., crayfish sampled in an area of 100-ft shoreline contour by 100-ft extension into the river channel, and clams and mussels sampled in variable benthic sledge tow areas). Table 2.3-8 provides the total number and type of invertebrate tissue data and the analyses performed on each sample. Invertebrate samples were analyzed for the same suite of chemicals as fish. Collocated surface sediment samples were also collected at clam and crayfish tissue sampling locations (or as close as possible) and analyzed for a similar suite of chemicals (Map 2.1-5).

2.2.3.10 Fish

The following fish species were selected as ecological receptors for the various feeding guilds in the lower Willamette River:

- **Omnivorous and herbivorous fish—**Largescale sucker (*Catostomus macrocheilus*), carp (*Cyprinus carpio carpio*), and pre-breeding white sturgeon (*Acipenser transmontanus*)
- **Invertivorous fish—**Sculpin (*Cottus asper*, *C. perplexus*, and C. spp.), peamouth (*Mylocheilus caurinus*), and juvenile Chinook salmon (*Oncorhynchus tshawytscha*)
- **Piscivorous fish—**Smallmouth bass (*Micropterus dolomieui*) and northern pikeminnow (*Ptychocheilus oregonensis*)
- **Detritivorous fish—**Larval stages of (ammocoetes and macropthalmia) Pacific lamprey (*Lampetra* sp.).

Fish tissue data collected by the LWG are included in the RI, BHHRA, and BERA data sets. In addition, data for adult Chinook salmon, adult sturgeon, and adult lamprey collected by other parties were included in the RI and BHHRA data sets. Table 2.3-10 provides the number of fish and invertebrates in each sample composite.

Fish species composites were based on individual fish collected over various reaches of the river. Sculpin were composited from areas similar to where crayfish were collected. The map locations are shown as centroids of the sampled area of 100-ft shoreline contour by 100-ft extension into the river channel (Map 2.1-5). Largescale sucker, peamouth, and northern pikeminnow were composited over 1-mile stretches (Map 2.1-6); smallmouth bass were composited over 1-mile reaches for Round 1 and composited from either side of the river over 1-mile reaches for Round 3 (Maps 2.1-7a-d); and black crappie, brown bullhead, and carp were composited over 3-mile reaches (Maps 2.1-8 and 2.1-9a-c).

Juvenile sturgeon samples were not composited. Map 2.1-10 shows sturgeon and juvenile Chinook salmon samples collected within discrete set line areas (for sturgeon) or beach seine areas (for juvenile Chinook). Three juvenile sturgeon were collected and individually analyzed for each of five reaches that ranged from 1 to 2 miles long. The 15 points on Map 2.1-10 show the individual locations of all sturgeon collected (three at each reach).

Pacific lamprey ammocoetes and micropthalmia were collected wherever suitable habitat was encountered (Map 2.1-11). For lamprey ammocoetes and macropthalmia samples, composites were made up of samples collected at several different areas within the Study Area and the map locations are shown as each successful sampling site of the sampling areas for each composite. Three ammocoetes collected during Round 1 were not analyzed. Note that collected lamprey ammocoetes and micropthalmia specimens were not positively identified to species because as larvae they are difficult to distinguish from other lampreys.

Whole-body and fillet tissue types were composited separately for carp, black crappie, smallmouth bass, and brown bullhead. During Round 1, fillets were collected from different fish than were used for whole-body samples, including black crappie, brown bullhead, carp, and smallmouth bass. During Round 3B, however, fillet and whole body data were obtained using the same fish. Fillets were removed from Round 3B carp and smallmouth bass, and fillets and bodies without fillets (i.e., remaining bodies) were composited and analyzed separately. Methods for calculating whole-body concentration for smallmouth bass and carp are provided in Appendix A4.

Stomach contents were also examined, and prey species were enumerated for juvenile Chinook salmon and juvenile sturgeon; stomach contents were analyzed for the same select chemicals relative to fish dietary risks. Collocated surface sediment samples were also collected at sculpin tissue sampling locations (or as close as possible) and analyzed for a similar suite of chemicals (Map 2.1-5).

2.3 REMOVAL ACTIONS COMPLETED

As part of the Superfund process, USEPA determines if "early action" cleanup (also called "removal action") is warranted for parts of the site that may be a threat to humans or the environment before the long-term cleanup for the site is completed. For Portland Harbor, these early action areas presently include Port of Portland Terminal 4, NW Natural, and BP/ARCO. Early action objectives for these sites include reducing ecological and human health risks associated with sediment contamination to acceptable levels and limiting the possibility of recontamination of sediments within the project area.

Other properties are either in early stages of planning for sediment cleanup or cleanup efforts are focused on upland areas. Planning continues for a non-time-critical removal action (NTCRA) to address contaminated sediments at Arkema, a former pesticide manufacturing facility at RM 7.3W. Upland source control, cleanup, and redevelopment have occurred at the Triangle Park site (RM 7.4E) under a bona fide prospective purchaser agreement with USEPA. Planning is also underway for a NTCRA to remove potentially erodible contaminated soils at the U.S. Moorings site (RM 6.2E), which has been used to berth and maintain USACE dredges and vessels.

2.3.1 Port of Portland Terminal 4, Phase 1

Terminal 4, owned and operated by the Port of Portland at RM 4.3E, was designated as an early action area based on the presence of pesticides, PCBs, metals, and PAHs above acceptable levels in sediment offshore of the site. The Port of Portland is conducting a NTCRA under a separate AOC for Removal Action, executed by the Port of Portland and USEPA in October 2003.

The NTCRA will be conducted in two phases. Phase I was completed in 2009 and consisted of dredging and offsite disposal of contaminated sediment adjacent to Berth 411 and Pier 5 in Slip 3 and north of Berth 414, dredging and offsite disposal of contaminated sediment adjacent to Berth 410 within Slip 3, construction of a nearshore cap at the head of Slip 3, and stabilization and capping of the Wheeler Bay shoreline. Phase II is pending and will consist of dredging, capping, and monitored natural recovery in areas not completely addressed by Phase I, and constructing a confined disposal facility in Slip 1.

2.3.2 NW Natural Phase 1

An early action cleanup was completed by NW Natural for the areas offshore of the Gasco/Siltronic facility (RM 6.5W) in 2005. Gasco is a former manufactured gas plant that deposited wastes containing PAHs, benzene, cyanide, and other hazardous substances into upland tar ponds. These ponds overflowed into the Willamette River on occasion, forming an erodible tar deposit that was visible at low river stages. Considered by USEPA to be a hot spot of contamination in the river, the goal of the early action was to reduce risk from known areas of uncontrolled contamination. Approximately 15,000 cubic yards of contaminated tar was dredged from the river and disposed of at an approved hazardous waste landfill. The area was then capped with organoclay materials.

2.3.3 BP/ARCO

An early action removal was performed with oversight by DEQ at the BP/ARCO facility (RM 4.9W) in 2008, in conjunction with improvements to the facility’s seawall. The primary contaminants found at the site were diesel fuel and gasoline in groundwater, which was migrating into the Willamette River. The early actions included 1) installation of an enhanced hydraulic control system in 2005 to more effectively contain petroleum hydrocarbons, 2) installation of a new sheetpile wall in 2007 to stabilize the facility and prevent groundwater migration of contaminants to the river, and 3) the removal in 2008 of a concrete revetment riverward of the new sheetpile wall, along with 13,293 cubic yards of underlying and nearshore contaminated sediment. The sediment was disposed of at an approved hazardous waste facility and clean fill was placed in the excavated area.